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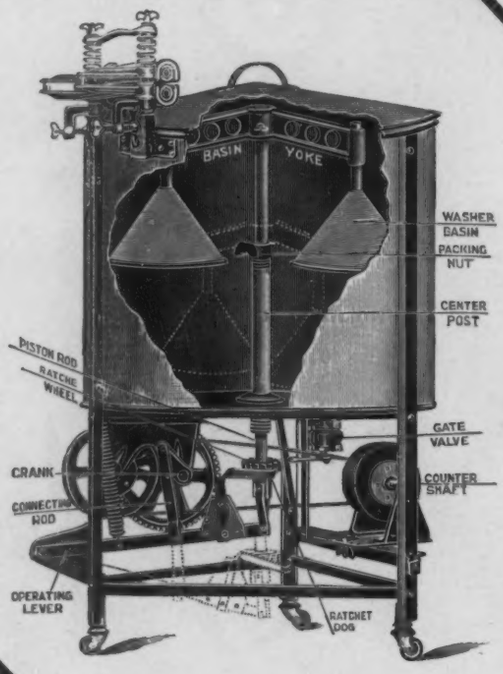
Alphabetical Index to Advertisers, Page 8 Where to Buy It in the West, Page 9

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# THE INTERPRETATION OF ELECTRIC CURRENT FLOW IN TERMS OF THE ELECTRON THEORY

BY W. F. DURAND.

In terms of the electron theory, in the form in which it seems to be most generally accepted at the present time, the electron together with the so-called positive atom constitute the ultimate units of matter. The electron is also negative electricity or at least is the seat of the negative charge while the positive atom is positive electricity or at least is the seat of the positive charge. Thus matter appears as an expression of positive and negative electricity in various degrees and states of aggregation and the electron theory reduces all physical and chemical phenomena to interpretation in terms of electricity or electrical charges and the ether; or to the mutual relations between electrons and atoms of positive electricity in aggregation and in motion relative to each other and to the ether as a universal containing medium. Whether ether will ever be reduced to electricity or electricity to ether or both to some tertium quid remains for the future to determine.

No one pretends, of course, that this concept of the material universe in general or of the constitution of the molecule in particular is final or that it more than marks a stage in the gradual development of a rational interpretation of the maze of physical and chemical phenomena with which we are surrounded. The present value of any hypothesis or theory lies not in the question of its finality, but rather in its effectiveness as an aid in the interpretation and related grouping of otherwise unrelated phenomena.

If therefore matter is reducible to expression in terms of elementary electric charges and if the relations between the ether on the one hand and such elements of matter in aggregation and motion on the other are competent to explain the physical and chemical facts of the universe, then properly directed study should serve to extend either the interpretation of mechanics, physics and chemistry in terms of electricity, or of electrical concepts and phenomena in terms of mechanics, physics and chemistry.

Thus in terms of the prevailing two fluid theory of electricity in vogue immediately preceding the electron theory, the satisfactory interpretation of the phenomena of current flow in metallic conductors was scarcely possible in terms of ordinary mechanics. It was impossible to obtain any satisfactory physical or mechanical interpretation of current flow **i**, resistance **R**, electro-motive force **E** or of their various relations and combinations.

The present paper is intended as a contribution toward such an interpretation in terms of the electron theory and ordinary mechanics.

This discussion of the subject has been prepared not unmindful of the pioneer work in this field done by Drude, Riecke, Lorentz and others. The mode of treatment here followed differs, however, in some respects from that followed by these earlier writers, especially in the concept and use of a mean time of action, and the development is carried into considerably further detail with special reference to the interests of the engineer rather than those of the physicist.

Familiarity with the general concepts of the electron theory will be assumed. It will be desirable, however, to review and develop in certain detail these general concepts as applied to the matter constituting any metallic conductor, or any metal in general. We therefore assume, for any such substance, serially as follows:

(1) The matter constituting a metal is composed of molecules in a state of close aggregation.

(2) Each molecule in an electrically neutral condition consists of one or more atoms of positive electricity associated with a certain number of electrons or negative units. The positive and negative charges thus in relation are equal in amount and hence the combination is neutral in its external relations.

(3) Of the electrons which thus enter into the formation of a neutral molecule, the bond of association for a certain number (presumably by far the greater part) is of an exceedingly stable character, while that for one or more others is relatively loose, thus permitting their detachment with more or less readiness.

(4) With one or more of the loosely attached electrons separated and momentarily flying free, the residual system exhibits the characteristics of positive electrification; while the electrons themselves exhibit the characteristics of negative electrification, or in essence they are negative electricity.

(5) The molecules as systems are in a state of vibratory or periodic motion, primarily in closed stationary orbits, though under certain conditions evidences of slow migration are found. The kinetic energy of this motion is manifest as sensible heat, and the potential energy relative to intermolecular forces represents the latent heat. The sum of the two represents the total heat energy of the body.

(6) As a result of the interplay of the forces between the loosely attached electrons and the residual stable systems, and between such electrons and others momentarily flying free, there results a rapid and continuous interchange of partners among the positive atoms and the loosely attached electrons. As a result of this interplay, the inter-atomic or intermolecular spaces are in some part occupied by free flying electrons, momentarily dissociated from their stable systems and flying about much as we picture for the molecules of an ordinary gas within an inclosing chamber. Various estimates have been made of the relative time spent by the electron in the attached state or in that of free flight. Whatever may be the proper value it seems likely that on the average the time spent in free flight is considerably less than that spent as constituents of neutral atoms. In any case it is sufficient for our purpose to assume that inter-molecular space stands in relation to these free flying electrons much in the way that ordinary space does to gaseous molecules in a condition of relatively similar density, and that while thus flying free and dissociated from the metallic molecules they are at liberty to respond to the influence of an accelerating force in accordance with the same laws as in the case of ordinary matter.

It should be especially noted that the positive atoms forming by far the larger part of the mass and bulk of the substance of a metallic body are anchored definitely in place and are subject to vibratory or periodic motions only and not to a motion of translation. Furthermore any force tending to accelerate the electrons (negative electricity) in one direction will act on the corresponding positive atoms in the inverse direction. There will be therefore no action on the metal as a whole. The free electrons will however be at liberty to respond individually to such an accelerating force while the positive atoms will not.

In brief then the electron theory for our present purposes implies for the interior of a metallic body the presence of free electrons ready to respond to a suitable accelerating force, with positive and neutral atoms anchored fast and subject to motion of a vibratory or periodic character only.

From this concept it follows further that with a body under the influence of no electric force the free electrons as a group or as a whole have no velocity relative to the metal. That is, their motion has no resultant vector value, no more than has that of the molecules of a gas in a closed chamber relative to the chamber itself. There is motion and momentum in every direction in space, but for every resultant in one direction there is an equal and opposite in the other. This is exactly analogous to the condition of the molecules of a gas within a closed chamber, and in many respects the status of the free electrons within a metallic body may be satisfactorily represented by the details of such an analogy.

With this by way of introduction, let us consider a closed metallic circuit, with the following characteristics:

Substance, uniform.
Cross section, uniform and of area **a**.
Length, **l**.
Number of free electrons per unit volume, **n**.
Total number of free electrons **N**.
Then we have:
Number of free electrons per unit length = **na** and

$$\mathbf{N = nal} \qquad (1)$$

It should be noted that **n** does not mean the number of detachable electrons per unit volume or the gross number which may, over a period of time participate in such movement, but rather the number per unit volume actually flying free at any one instant. If the unit of volume were sufficiently small and if the time basis of the count were likewise sufficiently brief, **n** would doubtless be a variable. With fixed physical conditions and for volumes and times which have significance for the problem in hand, **n** is a constant. For different substances or for varying physical conditions, and with special reference to temperature, **n** presumably becomes a variable, increasing with decrease of temperature and decreasing inversely.

Next let **m** denote the mass of an electron and **e** its electric charge, or in other words the amount of electricity (negative) represented by one electron.

Omission is purposely made of variation of mass in the electron with velocity. For velocities of the order presumably involved in conduction through metals, such differences are negligible.

Let us now assume an electric force of intensity **f** to act on the electrons along the line of the circuit. This force is to be considered as acting steadily and thus developing, during the times when the electrons are free to yield to such force, a uniformly accelerated motion along the line of the circuit.

The total force acting on an electron with charge **e** will be **fe**, and the consequent acceleration will be **fe/m.**

The result of the action of such an accelerating force will be to impress on the free electrons in addition to whatever actual velocity of flight they may have, a component velocity along the direction of the circuit. This may be called the impressed velocity to distinguish it in magnitude and direction from the actual velocity of flight which the electron may have as a result of the physical and thermal state of the metal.

Now at any given instant there will be **N** electrons flying free. Let **t** denote the time during which any one has been free and subject to the action of the accelerating force. Then throughout the entire group of **N** electrons **t** will have values varying from 0 for an electron just emitted up to some maximum value representing the longest period of free flight. Let **u** denote the impressed velocity for any given electron. Then

$$\mathbf{u} = \frac{\mathbf{fet}}{\mathbf{m}} \qquad (2)$$

There will be as many of these individual velocities as there are electrons or **N**. Denote the mean value

of **u** by **v** and the mean value of **t** by **z**, then we have

$$v = \frac{fez}{m} \quad \ldots\ldots (3)$$

This average velocity **v** is the velocity of translation for the **N** electrons as a group, and is, therefore, the group or statistical velocity for the entire aggregate of free electrons at any one instant.

Then relative to this group velocity **v** we have

**nam** = mass of electrons per unit length.
**namv** = group momentum per unit length.
**nae** = electric charge per unit length.
**naev** = electric momentum per unit length.

The latter expression is also the measure of the transfer of electricity (negative) past a given section in unit time, and is therefore a measure of current flow. We have, therefore, with the usual notation

$$i = naev \quad \ldots\ldots (4)$$

Again, for an individual electron, denote the kinetic energy relative to its impressed velocity by **k**. Then

$$k = \frac{mu^2}{2} \quad \ldots\ldots \text{(See Appendix 2.)} \ldots\ldots (5)$$

$$\text{and } \frac{dk}{dt} = mu \frac{du}{dt} \quad \ldots\ldots (6)$$

$$\text{But } u = \frac{fet}{m} \text{ (eq. (2))}$$

$$\text{and } \frac{du}{dt} = \frac{fe}{m}$$

$$\text{Hence } \frac{dk}{dt} = \frac{f^2 e^2 t}{m} \quad \ldots\ldots (7)$$

But **dk/dt** is, for a single electron, the time rate of energy change (increase) under the action of the accelerating force, and there will be **N** such elements of energy change, all of the same form. Hence the summation of such elements will be the time rate of change (increase) of the total kinetic energy of the system of **N** electrons relative to their impressed velocities. Denoting such total energy by **K** we have

$$\frac{dK}{dt} = \Sigma \frac{dk}{dt} = \Sigma \frac{f^2 e^2 t}{m} = N \frac{f^2 e^2 z}{m} \quad \ldots\ldots (8)$$

This is then the time rate at which the kinetic energy of the **N** electrons in free flight is increasing under the action of the accelerating force. But if we assume steady conditions, the kinetic energy of the free electrons as a group must actually remain uniform. It can neither continuously increase nor decrease. It must be subject therefore to a loss through absorption within the molecules at exactly the same rate as that of increase due to the action of the accelerating force.

In order to more clearly develop the situation, the character of the group movement of the free electrons must be considered in some further detail. The picture which we have formed of such movement implies for the individual electron a discontinuous history including periods of free flight and intermediate periods of absorption within the molecule. Such absorption of the electron within the molecule implies the disappearance of its free flight velocity and the absorption of its corresponding kinetic energy. In general therefore the kinetic energies of the free electrons relative to their free flight velocities become merged with those of the molecules upon their absorption by the latter. When such molecules again emit free electrons, their direction of flight at the instant of escape is as likely to be in one direction as another, and hence they will have, on the whole, no resultant velocity along the conductor and no energy relative to a group or translation velocity. It results that the act of collision with and absorption by a relatively fixed molecule robs the electron entirely of the energy corresponding to its share of the group velocity **v**, such energy being added to the heat content of the conductor and in the usual case ultimately dissipated as such. If this reasoning is correct, we may then identify the heating effect in the conductor with the energy absorbed from the free electrons, and quantitatively the time rate of such heat generation (**Ei** or $i^2 R$) with the time rate of energy transfer from the free electrons to the molecules of the metal. With this picture before us it is clear that the electrons serve simply as a carrier of energy from the source of the electric force through to the molecules where it becomes manifest as heat.

This relation enables us therefore to equate the time rate of the heating effect in the circuit, measured by **Ei** or $i^2 R$ in electrical terms, to the time rate of energy change in the group system due to the action of the accelerating force. We have therefore

$$Ei = i^2 R = \frac{N f^2 e^2 z}{m} \quad \ldots\ldots (9)$$

We next assume that the mean value of the time of action, **z** is determined by the physical conditions of the body and that it is constant under fixed physical conditions. (See appendix I.)

Then from (3)

$$fe = \frac{mv}{z}$$

and substituting in (8) we have

$$Ei = i^2 R = \frac{Nm\, v^2}{z} \quad \ldots\ldots (10)$$

But **Nm** is the total mass of the free electrons, **v** is the group velocity and **z** the mean time of action, is constant under fixed physical conditions. Hence the rate of work **Ei** or rate of heating $i^2 R$ is proportional to the kinetic energy of the free electrons relative to their group velocity in the circuit; and denoting such kinetic energy by **K** we have

$$Ei = i^2 R = \frac{2K}{z} \quad \ldots\ldots (11)$$

$$\text{or } K = \frac{Eiz}{2} = \frac{i^2 Rz}{2} \quad \ldots\ldots (12)$$

Equation (9) may also be written

$$Ei = Nfe \frac{fe\, z}{m} = Nfe\, v \text{ (see (3))}$$

But **Nfe** = electric force acting on entire group of free electrons. Denote this by **F**. Then

$$\mathbf{Ei} = \mathbf{Fv} = \text{force x velocity} \quad \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

= rate of doing mechanical work.

Again from (10) we have

$$\mathbf{E} = \frac{\mathbf{Nm\,v^2}}{\mathbf{iz}}$$

Substituting from (1) and (4) we have

$$\mathbf{E} = \frac{\mathbf{nal\,mv^2}}{\mathbf{naevz}} = \frac{\mathbf{m\,v\,l}}{\mathbf{ez}} = \mathbf{fl} \text{ (see (3)) } \ldots\ldots\ldots (14)$$

$$\text{Also } \mathbf{R} = \mathbf{E} \div \mathbf{i} = \frac{\mathbf{m\,v\,l}}{\mathbf{eznaev}} = \frac{\mathbf{m\,l}}{\mathbf{nae^2z}} \quad \ldots\ldots\ldots (15)$$

Let $\sigma$ denote specific conductivity.

Then by the definition of the term:

$$\mathbf{i} = \frac{\sigma\,\mathbf{a\,E}}{\mathbf{l}}$$

$$\text{whence } \sigma = \frac{\mathbf{li}}{\mathbf{a\,E}} = \frac{\mathbf{lnaevez}}{\mathbf{amvl}} = \frac{\mathbf{ne^2z}}{\mathbf{m}} \quad \ldots\ldots\ldots\ldots (16)$$

$$\text{or specific resistance} = \frac{\mathbf{1}}{\sigma} = \frac{\mathbf{m}}{\mathbf{ne^2z}} \quad \ldots\ldots\ldots (17)$$

The same expression may also be derived directly from the value of **R** in (15).

For the total accelerating force **F** we have

$$\mathbf{F} = \mathbf{Nfe} = \frac{\mathbf{nalmv}}{\mathbf{z}} \text{ (see (3))}$$

$$\text{or } \mathbf{F} = \mathbf{nae\ E} \text{ see (14)} \ldots\ldots\ldots\ldots\ldots\ldots (18)$$

$$\text{and } \mathbf{E} = \frac{\mathbf{F}}{\mathbf{nae}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (19)$$

Gathering these various results together we have

$$\mathbf{i} = \mathbf{naev} = \frac{\mathbf{nafe^2z}}{\mathbf{m}}$$

$$\mathbf{E} = \frac{\mathbf{mvl}}{\mathbf{ez}} = \mathbf{fl} = \frac{\mathbf{F}}{\mathbf{nae}}$$

$$\mathbf{R} = \frac{\mathbf{ml}}{\mathbf{nae^2z}}$$

$$\sigma = \frac{\mathbf{ne^2z}}{\mathbf{m}}$$

$$\mathbf{Ei} = \frac{\mathbf{Nmv^2}}{\mathbf{z}} = \mathbf{F\,v}$$

$$\mathbf{Ei\,z} = \mathbf{Nmv^2}$$

$\mathbf{i^2R} = \mathbf{Ei}$ as above.

$\mathbf{i^2Rz} = \mathbf{Eiz}$ as above.

$$\mathbf{F} = \mathbf{naeE} = \frac{\mathbf{NeE}}{\mathbf{l}} = \mathbf{Nfe}$$

$$\mathbf{Fl} = \mathbf{NeE}$$

Expressing these results in words, we have as follows: Current flow **i** is measured by the rate of flow of negative electricity past a given section in unit time, or otherwise by the electric group momentum of the free electrons per unit length.

With fixed values of **m** and **e** the electromotive force per unit length of circuit varies directly with the group velocity **v** and inversely with the mean time of action **z**. With a circuit under constant physical conditions the e.m.f. per unit length varies directly with the group velocity. Or otherwise the e.m.f. per unit length equals the intensity **f** and the total e.m.f. is measured by the work done by a force **f** acting through the length of the circuit **l**, or by the work done in moving unit charge through such length. Or otherwise the e.m.f. equals the total accelerating force divided by the electric charge carried by the free electrons per unit length of circuit.

With fixed values of **m** and **e**, the resistance varies directly as the length, and inversely as the cross section, as the number of free electrons per unit volume and as the mean time of action **z**.

With fixed values of **m** and **e** the specific conductivity varies directly as the number of free electrons per unit volume and as the mean time of action **z**.

The power **Ei** and heating effect $\mathbf{i^2R}$ vary directly as the kinetic energy of the group system **N** relative to the velocity **v** and inversely as the mean time of action **z**. Or otherwise they are both measured by the product **Fv** the rate at which the force **F** does work on the electrons in the circuit.

The total force **F** is measured by the product of the e.m.f. and the electric charge carried by the electrons per unit length.

Suppose a system of units, the most fundamental possible in nature, and in which the unit of mass is the mass of the electron and the unit of electric quantity or charge is that carried by the electron. Then in the above equations both **m** and **e** will become unity and the various expressions will become much simplified. It will be of interest for the reader to pass these various equations and expressions in review with this simplification and to note the physical or mechanical interpretation in such simplified form. This will serve to bring out in the plainest possible manner the relation between the various electrical quantities and the specifications of the circuit as determined by the physical characteristics **a, l, n, z.**

## APPENDIX I.

Regarding the assumption that the mean time of action **z** is constant under fixed physical conditions, the following points may be briefly noted.

Picture the **N** free electrons at any instant. These individual electrons will have varying free paths tranversed in varying times and beginning and ending at varying instants of time. In particular the times of free flight will vary between certain limits and according to some law of distribution about a most frequent value.

Picture again the same **N** free electrons at any instant. Individually they have been free and under the action of the accelerating force for periods of time varying from zero for an electron just escaping from an atom to the time of flight for the longest free path.

We have then two kinds of time intervals to consider and two mean times

(1) The times of free flight and their mean.

(2) The times of action of the accelerating force and their mean.

Now from the known values of the masses and forces involved and from such inference as can be applied to the problem, we must assume that the actual velocities of the electrons in free flight are high. We may not unreasonably

assume velocities of the order of .001 that of light or even higher. On the other hand, our best knowledge of the factors involved shows a very low value for v, the group velocity of translation.

Thus following such estimates as have been made let us take one ampere per second or one coulomb equal to $8.79 \times 10^{18}$ electrons, and the number of free electrons per cubic centimeter of copper of the order $380 \times 10^{18}$. We shall then have by way of illustration for a No. 8 copper wire carrying a current of 25 amperes an actual group velocity of the order of 7 centimeters or a little less than three inches per second. More generally with these same estimates we shall have

$v = 4570\ i/d^2$ centimeters per second.

$= 1870\ i/d^2$ inches per second.

Where

$i$ = current in amperes.

$d^2$ = circular mills in conductor.

These results show the very low order of group velocity which is entirely competent to explain the facts of current flow.

It follows that impressed velocities of this order will have no measureable influence in lengthening or shortening the time of free flight of bodies moving actually with enormously greater velocities and hence no matter what current may be flowing, the velocity of translation will not sensibly affect the times of free flight or the mean of such times.

It follows that the times of action as above defined will be similarly independent of the amount of current flow, and hence for any given substance under constant physical conditions such individual times and their means may all be assumed independent of the e.m.f. and the current flow, and dependent solely on the nature and physical state of the body.

It may be here stated, without detailed proof, that examination shows the mean time of action, as here defined and used, to be one-half the mean free time of flight, or one-half the mean free life of the electron.

## APPENDIX II.

The measure of the change in the kinetic energy of the electrons due to the action of an accelerating force acting along the line of the conductor may be developed as follows:

At any time t after its emission let the component velocity and direction of motion of an electron, so far as due to forces other than the accelerating force, be w in a direction $\theta$ with the line of action of the accelerating force.

Let the velocity due to the accelerating force which has been acting during the time t be u in the line of action of the force, u being small compared with w.

Then the actual velocity at this instant will be the resultant s given by

$$s^2 = w^2 + u^2 + 2wu\cos\theta.$$

Let k = kinetic energy. Then

$$\frac{1}{m}\frac{dk}{dt} = \frac{d}{dt}\frac{s^2}{2} = w\frac{dw}{dt} + u\frac{du}{dt} + wdu\cos\theta + udw\cos\theta$$

This is the time rate of change of the kinetic energy of one electron. There will be N such elements and in the summation of the enormous number actually involved we shall have statistically an indefinite approach toward equal positive and negative summations for the terms $w\frac{dw}{dt}$, $wdu\cos\theta$ and $udw\cos\theta$. That is, for every value of w with a positive value of dw there is likely to be found an equal value of w with an equal negative value of dw and for any combinations of either wdu or udw with a positive value of $\cos\theta$ there is likely to be found an equal combination with an equal negative value of $\cos\theta$. Hence in the summation all terms will vanish at the limit except $u\frac{du}{dt}$, and we shall have therefore

$$\frac{dK}{dt} = \Sigma\frac{dk}{dt} = \Sigma mu\frac{du}{dt} = \frac{Nmv^2}{z}$$

as in (6), (7), (8), (10).

## ELECTRIC RAILWAYS IN COLORADO.

Preliminary figures of the forthcoming quinquennial report on the electric railways of the state of Colorado have been given out by Director W. J. Harris, of the Bureau of the Census, Department of Commerce. They were prepared under the supervision of W. M. Steuart, chief statistician for manufactures.

The statistics relate to the years ending December 31 for 1912 and 1907, and June 30 for 1902. The totals include the electric division of a steam road and electric light plants operated in connection with electric railways and not separable therefrom, but do not include railways under construction which had not begun operations during the census year.

The figures as presented for Colorado show that during the decade 1902-1912 there were substantial gains in the industry. The increase of the 16 operating companies reported in 1912 over 1902 was 8, or 100 per cent, and their aggregate gross income shows an increase of $4,402,714 (198 per cent), and their net income increased $867,605 (222 per cent) over 1902. The miles of track were increased 233 (100 per cent), and the number of revenue passengers carried was 44,226,000 more in 1912 than in 1902, an increase of 104 per cent.

The figures in detail are shown in the accompanying table:

| Colorado. | 1912. | 1907. | 1902. | Per cent of increase:[1] 1902-1912. |
|---|---|---|---|---|
| Number of companies | 17 | 11 | 9 | 88.9 |
| Operating | 16 | 11 | 8 | 100.0 |
| Lessor | 1 | .. | 1 | ..... |
| Miles of line | 348.43 | 206.36 | 154.17 | 126.0 |
| Miles of single track | 467.97 | 317.37 | 234.53 | 99.5 |
| Cars, number | 785 | 631 | 393 | 99.7 |
| Passenger | 551 | 474 | 352 | 56.5 |
| All other | 234 | 157 | 41 | 470.7 |
| Persons employed | 2,498 | 1,738 | 1,053 | 137.2 |
| Salaried employes | 226 | 133 | 74 | 205.4 |
| Wage earners (average number) | [2] 2,272 | 1,605 | 979 | 132.1 |
| Power plant equipment: | | | | |
| Horsepower, total | 48,532 | 21,790 | 9,690 | 387.3 |
| Steam and gas engines, including turbines: | | | | |
| Number | 28 | 23 | 32 | —12.5 |
| Horsepower | 43,332 | 19,910 | 9,710 | 346.3 |
| Water wheels: | | | | |
| Number | 5 | 5 | 1 | ..... |
| Horsepower | 5,200 | 1,880 | 250 | ..... |
| Kw. capacity of dynamos | 29,692 | 13,634 | 6,275 | 373.2 |
| Output of stations, kw.-hr | 97,915,436 | 42,110,616 | 17,859,576 | 448.3 |
| Current purchased, kw.-hr. | 8,458,015 | [3] | [3] | ..... |
| Passengers carried | 107,502,972 | 93,683,653 | [4] 52,327,717 | 105.4 |
| Revenue | 86,597,205 | 73,458,468 | 42,371,590 | 104.4 |
| Transfer | 18,813,014 | 18,362,433 | 9,956,127 | 89.0 |
| Free | 2,092,753 | 1,862,752 | [3] | ..... |
| Car mileage (passenger, express, freight, etc) | 17,202,137 | 14,596,838 | [4] 8,925,060 | 92.7 |
| Condensed income account, operating companies: | | | | |
| Gross income[5] | $6,630,480 | $4,483,254 | [4] $2,227,766 | 197.6 |
| Operating expenses | 3,264,753 | 2,099,421 | 1,300,606 | 151.0 |
| Gross income less operating expenses | 3,365,727 | 2,383,833 | 927,160 | 263.0 |
| Deductions from income (taxes and fixed charges) | 2,106,967 | 1,273,024 | 536,005 | 293.1 |
| Net income | 1,258,760 | 1,110,809 | 391,155 | 221.8 |

[1] A minus sign (—) denotes decrease.

[2] Number employed Sept. 16, 1912.

[3] Figures not available.

[4] Exclusive of 1 company which failed to furnish this information.

[5] Income from sale of current for light and power included: 1912, $1,064,247; 1907, $344,468; and 1902, $111,104.

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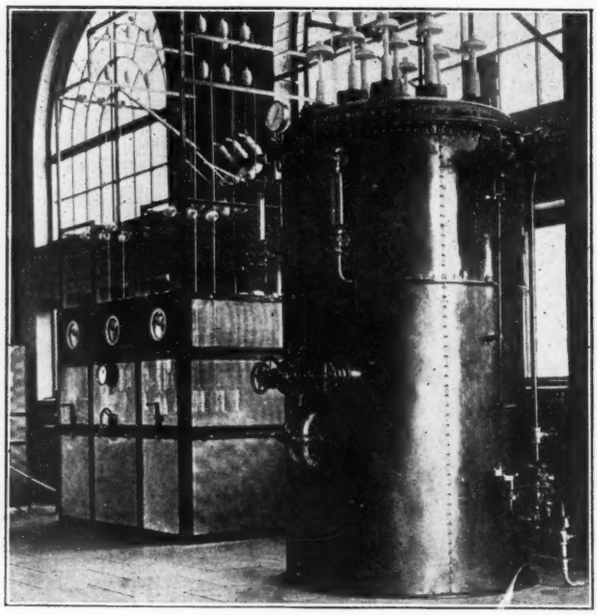
**Normal wet concrete carrying currents increases its resistance a hundred-fold or more in the course of a few weeks, which fact still further lessens the danger of trouble due to electrolysis.**

## GENERATING STEAM ELECTRICALLY.

BY ERNEST KAISER, M. E.

For utilizing surplus hydroelectric energy there has been developed in Europe a high voltage, alternating current electric boiler which can be run on the primary current, without transformer. For a number of years plants consisting of units with capacities ranging from 500 kw. up to 2000 kw. each and voltages from 2200 up to 12,000 volts, have been in continuous operation. The first plant on this side of the Atlantic is in course of erection in Eastern Canada, comprising two single units of 750 kw. each, on 2400 volt, three-phase current, star connected, to produce steam of 125 lb. pressure for heating a cotton mill during the night hours.

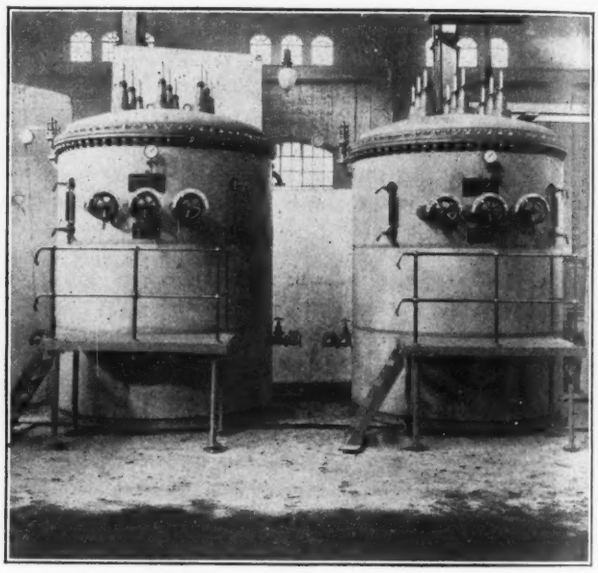


First Electric Boiler Installation.

In countries, like Canada or Sweden, where coal is comparatively expensive and the cost of water development low, there are quite a number of cases when the production of hydroelectric steam warrants the initial cost of additional development of the hydraulic end, especially on the consideration of building a manufacturing plant, like a mechanical pulp mill, nearer to its source of raw material. Still oftener it is economical to equip the mechanical-electrical end of a hydroelectric development before its ultimate completion, when needed to satisfy an enlarged local demand for light and power, as in many cases where space has been provided for future hydraulic turbo-generator sets. Furthermore standby hydraulic generator sets can often be thus utilized to pay their initial cost, while being ready at a moment's notice to be switched off the electric boilers into service on the line.

In localities where fuel-oil is cheap, as in California or in Russia, hydroelectric steam has its special field. In standby stations for hydroelectric systems, a part of the steam boiler battery is constantly kept supplied with warm water and steam, so as to be ready on short notice, in case of an emergency, to supply the line with current. The practice is to alternately heat one boiler at a time and keep each boiler connected with the other boilers of a battery. The fuel consumed for this stand-by service which may not be called upon for a long time, is quite considerable in some plants, and where there is a hydroelectric surplus, constantly or off-peak, a sufficient saving can often be shown to warrant the additional cost in two or three years, as this electric steam equipment is relatively inexpensive.

There are no changes in the outlay of a steam station necessary as the electric boilers can be run parallel to the fuel-oil boilers, feeding directly into the main steam pipe of the fuel-oil boiler battery. The



Canadian Installation of Electric Boilers.

space needed for an electric boiler plant is rather small. For instance a boiler of 2000 kw. capacity measures 8 ft. in diameter and 12 ft. in height, a 750 kw. boiler 6½ ft. in diameter and 11 ft. in height.

The thermal efficiency of these boilers is claimed to be 98 per cent, the builders guaranteeing 93 per cent on full load and 88 per cent on half load. For a preliminary estimate one can assume that 1 kw.-hr. produces about 3 lb. of saturated, dry steam at commercial pressures up to 125 lb.

It would lead too far to give full details of the boiler in a short article, especially to show, why by means of some of the patented features of this boiler, this boiler operates successfully when so many previous attempts towards this end have utterly failed. It may suffice to state that the water itself is used as a resistance, the current being taken into the boiler to a fixed electrode and divided into a primary current which travels between the fixed electrode and a movable electrode, and into a secondary current. The electrodes are within non-conducting tubular bodies that take in the water on one end and discharge the steam on the other end. The electrodes are arranged in groups and all surrounded by water within the boiler.

By shifting on the boiler the distance between the electrodes and by switching on or off the various

groups, on the switchboard, a fine regulation in all steps from full load to one-third of its capacity can be attained. The supply of feed water is usually regulated by the help or can be made automatic, the quality of water has to be the same as for a first class fuel-steam boiler. The equipment is made to approve with the fire underwriters' regulations, the risk being smaller than with ordinary coal boilers.

The boiler is designed to avoid accidents automatically by its own inner working, and is said to be fool-proof. The builders state that it needs little attention, that no scale is formed, and few repairs necessary, the only parts that have to be renewed every few years being some inexpensive iron electrodes.

Similar to this application in stand-by stations, where the fuel-oil boiler battery offers the natural heat storage into which the electric boiler empties, there are smaller projects of using electric boilers in isolated stations for heating purposes, where in off-peak hours an electric boiler stores its surplus into a reservoir. For example an old Scotch boiler shell can be thus used as a container under pressure.

## GAS BUOYS ALONG THE CANAL.

In conformity with Section 4678 of the Revised Statutes of the United States all the buoys in the Canal are colored and numbered, so that in entering the channel at Colon, and extending south to Miraflores Locks, red buoys with even numbers shall be passed on the starboard hand, and black buoys with odd numbers on the port hand. On entering the channel at Naos Island, and extending north to Miraflores Locks, at the Pacific entrance, red buoys with even numbers are placed on the starboard hand, and black buoys with odd numbers on the port hand.

Buoys on the port side will use double flashes, those on the starboard, single flashes, as follows: Buoys on starboard tangents have a characteristic of five seconds light, five seconds dark; on port tangents, two seconds light and one second dark, two seconds light, 3.8 seconds dark. Turning buoys on the starboard hand have a characteristic of .3 second light, 2.7 seconds dark; on the port hand, .3 second light, .7 second dark, .3 second light, 1.7 seconds dark.

The general custom for channel or river lighting is to have red lights on the starboard hand and white lights on the port hand, but with the perfection of devices which produce rapid flashes of whatever duration desired, it is likely that this method will eventually be superseded by the method of single and double flashes of white light on either side of the channel, especially in localities frequented by heavy fogs and rains, where the maximum efficiency of a light is required. To obtain a red light it is necessary to use ruby glass, and such glass absorbs about 75 per cent of the light. At the Atlantic and Pacific entrances to the Canal, parts of which may be navigated without Canal pilots, red flashing lights will be tentatively used on the starboard hand, but in all other parts of the Canal white lights will be used unless they are proved to be confusing.

## PROPOSED HYDROELECTRIC BILL.

*(On February 7, 1914, Mr. Jones introduced the following bill in the United States Senate. It was read twice and referred to the Committee on Irrigation and Reclamation of Arid Lands. It is commented upon in our editorial, "Aiming to Aid," which appeared in our last issue.—The Editors.)*

**A Bill (S. 4415),**

**To aid and to regulate the development, operation, and maintenance of water powers on lands of the United States, and for other purposes.**

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled:*

**That in order to utilize for the benefit of the public the waterpower resources of the public lands of the United States, and in order to prevent the unregulated monopoly of said water powers, the right to construct, develop, maintain, and operate storage reservoirs, canals, conduits, waterpower or hydroelectric plants, transmission and distributing lines, and all other appurtenant constructions and appliances on, over, and across any part of the public lands of the United States, reserved or unreserved, including national forests and Indian reservations (but excluding national parks, monuments, and military or other lands reserved for governmental purposes), is hereby granted, upon compliance with the conditions hereinafter imposed, to any state or municipal subdivision thereof or to any public service corporation organized for the purpose and authorized by the state or states in which any portion of such dam, storage reservoir, waterpower or hydroelectric plant, or transmission or distributing lines may be located, to engage in the business of furnishing to the public water for domestic, irrigation, transportation, or any other purpose, or light, heat, power, or energy generated by electricity or otherwise. Such state, municipal subdivision, or public service corporation is hereinafter referred to as the "grantee."**

**Sec. 2. That any grantee hereunder may construct, develop, maintain, and operate water-storage reservoirs, canals, conduits, waterpower or hydroelectric plants, transmission and distributing lines, and all other appurtenant structures and appliances on, over, and across any part of the public lands of the United States, reserved or unreserved, including national forests and Indian reservations (but excluding national parks, monuments, and military or other lands reserved for governmental purposes), upon filing with the Secretary of the department having jurisdiction over such lands plans and specifications for such works, together with such drawings of the proposed construction and such map of the proposed location and flooded area as may be required for a full understanding of the subject, which plans, specifications, and drawings shall be approved by such Secretary if it appears to him that the proposed development will promote the highest and greatest practicable use of the water resources involved. Within ninety days after the approval of such plans, specifications, and drawings said grantee and such Secretary shall agree upon the then fair market value of the lands proposed to be occupied which are owned or controlled by the United States, and in the event of their failure to agree within such time, then such grantee shall have the right to, and may, begin proceedings in the district court of the United States for the district in which such lands or any part thereof may be located for the purpose of determining the then fair market value thereof. Such district court is hereby given jurisdiction of said proceedings for such purpose, and service of process may be had upon the clerk of said court, and upon such service being made the Attorney General of the United States shall enter his appearance for the United States. Such proceedings shall be conducted according to the laws**

Upon an agreement being reached as to the fair market value of said land between said Secretary and the grantee, or in the event of their failure to agree, then upon the final adjudication of the value of said land by said court the grantee shall have the right to occupy said land for the purposes above set forth for a period of fifty years after such agreement or final adjudication, and after the expiration of said period of fifty years such right shall continue until compensation has been made to the grantee for the fair value of its property as herein provided. During the occupancy of said land by the grantee it shall pay into the treasury of the United States annually, in advance, a sum equal to five per centum upon the fair market value of such land as so determined by agreement or final adjudication, and the liability for such payment shall constitute a preferred claim against all the assets of the grantee and may be collected by suit brought in the name of the United States, and in the event of the failure of the grantee to pay any judgment and costs recovered in such suit, then such judgment may provide for ejecting said grantee from said premises and for the forfeiture of the grant.

Sec. 3. That in the acquisition of the property of the grantee, as hereinafter provided, no value shall be claimed by or allowed to the grantee for the use of or the right to aud rules in force in said jurisdiction at said time for the exercise of the right of eminent domain for public purposes. use the lands acquired under the terms of this act, but in any adjudication for rate-making purposes by any court or public service commission the rental so paid shall be included as a necessary operating charge.

Sec. 4. That at any time after the expiration of the said fifty years congress may terminate the right to occupy such land and provide for the taking over by the United States, or by any state within which such land may be located, or by any municipal subdivision of such state, of all of the property of the grantee dependent for its usefulness upon the rights hereby granted, which shall include all necessary and appurtenant property created or acquired and valuable or serviceable in the distribution of water, or in the generation, transmission, or distribution of light, heat, power, or energy, and by paying to the grantee the fair value of said property, and assuming all contracts entered into by said grantee which have the approval of the duly constituted public authority having jurisdiction thereof, or which were entered into in good faith and at a reasonable rate in view of all the circumstances existing at the time such contract was made. Unless otherwise provided by congress, the method of determining the fair value of said property, and the reasonableness and good faith of such contracts, shall be by agreement between the Secretary or Secretaries of the department or departments then having jurisdiction over such lands and the grantee, and in the event of their failure to agree, then by proceedings instituted by the United States in the district court of tne United States within which such land may be located.

Sec. 5. That in order to prevent tying up, for speculative purposes, any of the lands to be acquired under this act, the grantee shall commence the construction of the project within two years from the date of the agreement, or in the event of failure to agree then the date of final adjudication, as to the value of the land to be occupied, and shall thereafter, in good faith, continuously, and with due diligence, prosecute such construction, and shall within the further term of five years complete and put in commercial operation such part of the ultimate development as the Secretary or Secretaries of the department or departments then having jurisdiction over such lands shall deem necessary to supply the reasonable needs of the then available market, and shall from time to time thereafter construct such portion of the balance of such ultimate development as said Secretary or Secretaries may direct and within the time specified by said Secretary or Secretaries, so as to supply adequately the reasonable market demands until such ultimate development shall be completed, and no extensions of the periods herein specified shall be granted except by the President, and then only when, in his judgment, the public interest will be promoted thereby.

Sec. 6. That rates charged by all grantees under this act shall be reasonable and the service and operation shall be adequate and efficient, and all such grantees shall be subject to lawful regulation in the public interest as to rates and otherwise by the respective states having jurisdiction thereof: Provided, however, That the United States reserves the right to regulate rates and service to the consumer should the business of the grantee be or become interstate, or should the states or local authority fail to regulate such rates or service.

Sec. 7. That the rights granted by this act shall, upon application, inure to the benefit of any state, municipal subdivision thereof, or public service corporation, as defined herein, which is now constructing or operating any dam or accessory works, or any water storage reservoir, or waterpower or hydroelectric plant, or any transmission or distributing lines and their appurtenances or appliances on the public domain, provided such state, municipal subdivision thereof, or public service corporation shall comply with all the terms and provisions hereof.

Sec. 8. That all waterpower reserves may be opened by the President to location, settlement, entry, and disposal under the appropriate public land laws, so far as the same will not impair, prejudice, or destroy the use of the land for waterpower development, generation, transmission, or utilization, it being the intent of this section that so far as possible lands available and necessary for waterpower and for other purposes shall be used for all purposes, the waterpower, however, being the dominant use, which reservation shall be expressed in all patents issued for such land.

Sec. 9. That the works constructed and maintained under authority of this act shall not be owned, leased, trusteed, possessed, or controlled by any device or in any manner so that they form a part of or in any way affect any combination in the form of an unlawful trust, or form the subject of any contract or conspiracy to limit the output of electric energy or in restraint of trade with foreign nations or between two or more states or territories, or within any one state or territory in the generation, sale, or distribution of electric energy.

Sec. 10. That all acts and parts of acts inconsistent with this act are hereby repealed, and the right to alter, amend, or repeal this act is hereby expressly reserved.

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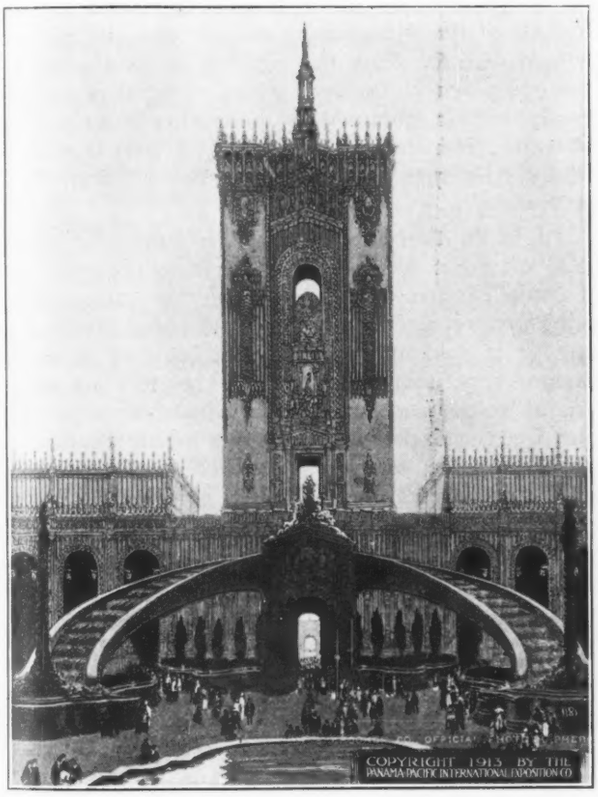
**The largest system of electric railways** in Canada is at Vancouver, B. C., where the British Columbia Electric Railway Company, Ltd., has a total mileage in operation as of December 31, 1913, of 371 miles. During the year the lines around Vancouver city were extended by the addition of ten miles of trackage, but a larger development took place on Vancouver Island where the Victoria city system was extended 26 miles up the Saanich peninsula, opening up a very rich agricultural and summer resort district. During the year the company have added to their rolling stock three double truck passenger cars, 60 freight cars, 3 sweepers, 15 logging cars and two combination passenger and mail cars. The total equipment at present consists of 902 cars.

## LIGHTING EFFECTS WITH GAS AND STEAM.

BY WALDEMAR H. F. N. DE BILLE.

Steam and gas will be extensively used in some of the original schemes for night illumination of the Panama-Pacific International Exposition. It is believed that some of the most spectacular effects will be gained where these are combined.

This will be particularly noticeable in the Court of Abundance in which the architect has taken for his theme the creation and development of the earth and has presented a symbolic idea of the history of man from the prehistoric day to the present. The rise of man and the development of the earth has been treated by a series of graduated scales; the lowest form, or the




Cascades of the Court of Abundance.

unicellular life being presented on the ground level and the various stages of advance noted on ascending planes.

The court will be illuminated almost exclusively by means of high pressure gas. Urns will be placed about the court and on the borders of a still lagoon in the center, from which twisted gas flames ten to fifteen feet in height will rise.

Great sheets of flame will lick the fire-proof sides of the court and rise along the facades and up the scores of columns supporting huge carved figures of prehistoric men.

A haze will hang over the entire court created by steam forced through perforated pipes laid along the ground level. The cloudy vapor and the reddish-yellow flames will produce an effect of mystery which the entire architectural scheme will carry out.

It is the intention of the designer to have gas released under pressure just beneath the surface of the water in the lagoon which will be ignited upon striking the air. The details of this ingenious plan, however, have not yet been worked out.

As a substitute for the usual pyrotechnic displays, steam will be used at the Panama-Pacific International Exposition. While this is not unique, having been successfully used to a slight degree at the Hudson Fulton celebration in New York, this will be the first occasion upon which it will take the place of fireworks.

Set pieces of pipe in various shapes are being made and placed near the Scintillator—a battery of forty-eight 36-inch searchlight projectors—on the bay front of the site. Through these pipes steam under high pressure will be forced to a height of three hundred feet or more. An automatic device at the base will cause the steam to be turned on for a certain number of seconds and then shut off.

The vapor will assume form under the colored rays of the Scintillator, waver and dissolve like wraiths into the upper air.

The gas used at the Exposition will be distributed through a high pressure system by a San Francisco company and will be the oil gas made of crude petroleum commonly used in California. Its heat value is 600 B.t.u. per cu. ft. and it has a candlepower value in excess of 18. Being exceptionally free from sulphur and other impurities it will be used for heating in all of the buildings. A low pressure system will also be operated at about six inches water pressure for lighting purposes in the various buildings.

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### FREE MOTORS FOR P. P. I. E. EXHIBITORS.

**A communication has just been received by the Panama-Pacific International Exposition from one of the largest manufacturing concerns of electrical motors, offering the free use of as many motors as are desired by exhibitors at the Exposition.**

**The Exposition has been anxious to have as many exhibitors as possible operate their machinery under regular working conditions in order that the public may see just how the various products are made and that intending purchasers of machinery may judge the comparative merit under working conditions.**

**This offer from a large electrical firm, which will unquestionably be duplicated by others, will be of great assistance in promoting this undertaking.**

**The various conditions specified by the electrical company follow:**

**"1st. The exhibitor to pay all transportation charges to and from nearest free delivery point.**

**"2d. Exhibitor to pay for all repairs other than ordinary wear and tear.**

**"3rd. Exhibitor to furnish any special pulleys or couplings. We will furnish standard pulleys free of charge.**

**"5th. All consignments to be handled by district office in whose territory exhibitor is located.**

**"7th. The exhibitor should understand that we reserve the right to hang a suitable sign on the motor, stating that it was loaned by us."**

**The offer is made generally for motors up to and including twenty-five horsepower, but the communication explains that in the event that a larger motor is desired the application should be made in a different manner. The fourth and sixth clauses refer to the details of making application for the loan.**

**It is believed by the Exposition that an arrangement may be made whereby the products of the exhibitor manufactured on the ground may be profitably handled by him.**

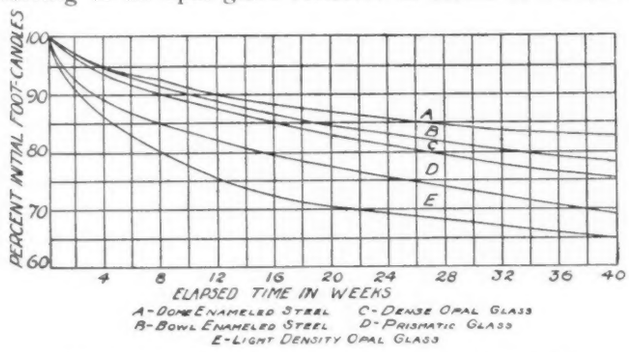
# LIGHTING METHODS

## PLANNING LIGHTING INSTALLATIONS.

BY J. B. JACKSON.

(Concluded.)

The collection of dust and dirt affects different reflectors in varying degrees as is shown by the diagram which is presented by the courtesy of the National Lamp Works of General Electric Company, giving graphic representation of tests made at Cleveland. The vertical scale representing per cent of the initial illumination value and the horizontal scale the time elapsed is weeks. Curve A represents the results obtained from a dome shaped enameled steel reflector; Curve B, a bowl shaped reflector of the same material; Curve C, a heavy density opal glass; Curve D, Prismatic Glass; Curve E, Light density Opal. In referring to an opal glass reflector in terms of its density it must be remembered that the term density refers to optical not physical density and is also independent of the thickness of the glass. The lighter density the opal, the higher is the light transmission value. The Prismatic glass used in the test was the type which is familiar to all, consisting of a reflector of clear glass with carefully designed prisms on the exterior surface.




Effect on Intensity of Illumination Due to the Collection of Dirt and Dust on Lamps and Reflectors.

Contrary to the general belief these tests show that prismatic glassware is not affected by dirt to as great a degree as is the light density opals. Under this latter classification will come the most of the opal glass which is being used commercially. These tests did not include any figures on indirect lighting but it has been stated, as a result of tests made that the figures of 10 per cent per month holds for at least the first two months when mirror reflectors are used. As this last figure corresponds fairly well with results on the curve it would indicate that the position of the reflector has not as great bearing as has been supposed.

If we would set 15 per cent as the allowable depreciation on lamps and reflectors the cleaning period would be six weeks for indirect, Prismatic, light and medium density opal reflectors; and 16 weeks for steel and heavy density opal reflectors.

The designer of lighting installation can accomplish a great deal by impressing upon his client the necessity of regular cleaning periods. It is not uncommon that installations have been known to be allowed to go without cleaning for a period of more than a year. Such an installation might give only 25 to 50 per cent of its initial illumination value, if the reflector used were of light density opal.

In referring to systems of lighting, three terms have come into general use, Direct, Semi-Indirect and Indirect. The lines of demarcation between these classes are rather hard to draw, but present definitions are about as follows; the term Direct lighting is applied to systems in which a large part and in some cases all of the illumination on the working plane is received directly from the lighting units (lamps and their equipment); Indirect when no light is received directly but is obtained by reflection from ceilings and walls; Semi-Indirect when only a part is received directly, the greater percentage being obtained indirectly.

Light on the working plane is composed of two parts, the light received directly from the unit, plus a portion of that directed toward the walls and the ceiling and reflected back upon the plane of illumination. It is evident therefore that color of walls and ceilings very materially affect the total illumination, as color is an indication of the absorption of light, i. e. the darker the color the higher the absorption value; the exception to the above rule being units which direct practically all of the light toward the working plane.

**Table 4—Watts Per Square Foot to Produce One Foot Candle Illumination. (Watts Per Lumen.)**

| Type of Lighting Equipment. | Ceiling Light. Walls. Light. | Ceiling Light. Walls. Medium. | Ceiling Light. Walls. Dark. | Ceiling Medium. Walls. Light. | Ceiling Medium. Walls. Medium. | Ceiling Medium. Walls. Dark. | Ceiling Dark. Walls. Medium. | Ceiling Dark. Walls. Dark. |
|---|---|---|---|---|---|---|---|---|
| Mirror (Bowl Type Direct) | .180 | .186 | .196 | .183 | .193 | .196 | .196 | .196 |
| Prismatic (Clear) | .180 | .204 | .208 | .225 | .240 | .263 | .263 | .270 |
| Prismatic (Satin Finish) | .230 | .251 | .277 | .257 | .277 | .309 | .309 | .337 |
| Prismatic (Velvet Finish) | .200 | .220 | .240 | .220 | .240 | .251 | .277 | .284 |
| Opal Enclosing Unit | .300 | .327 | .360 | .384 | .372 | .416 | .491 | .540 |
| Prismatic Enclosing Unit | .216 | .230 | .245 | .240 | .251 | .284 | .300 | .309 |
| Opal Reflector (Heavy Density) | .200 | .208 | .225 | .216 | .225 | .235 | .235 | .235 |
| Opal Reflector (Medium Density | .216 | .235 | .251 | .240 | .251 | .284 | .292 | .300 |
| Opal Reflector (Light Density) | .229 | .251 | .277 | .263 | .277 | .308 | .318 | .327 |
| Enameled Steel Dome Shaped) | .204 | .216 | .225 | .208 | .220 | .225 | .225 | .225 |
| Enameled Steel (Bowl Shaped) | .225 | .235 | .245 | .229 | .240 | .245 | .245 | .245 |
| Semi-Indirect | .251 | .284 | .318 | .386 | .415 | .470 | Not recommended. | |
| Indirect (Mirror Reflector) | .349 | .386 | .415 | .514 | .568 | .635 | Not recommended. | |
| Bare Lamp | .270 | .309 | .372 | .309 | .272 | .432 | .450 | .514 |

**Color Classification.**

| Light. | Medium. | Dark. |
|---|---|---|
| White | Yellow | Green |
| Light Gray | Light Blue | Brown |
| Cream | Light Buff | Red |

In planning a lighting installation it is essential to consider all the quantities which affect the illumination results, namely, architectural features intensity required, kind of lamp, type of auxiliary equipment, decorations, etc. In order to simplify matters

as much as possible a table has been made up containing all these variables excepting the intensity required for the service. In doing this it has been necessary to assume a lamp for general use for this purpose, the 100 watt Mazda lamp of the January, 1914, rating has been selected. In making calculations average lamp depreciation of 3.6 per cent has been allowed for. However, the large sizes of lamps will give somewhat higher results while the smaller sizes will give lower, so for the exact values of lamps other than the January, 1914, 100 watt Mazda multiply results in the table, by the quantity under multiplying factor in the table of Lamp Values, Table 1.

Below Table 4, is given three colors under each of the classifications, Light, Medium and Dark, these are given as a guide for classifying the different conditions of ceiling and walls. Figures are given in three places although no especial significance should be attached to the last decimal place.

### Problem.

As an example of the method of calculation, assume the following conditions:

Width of space ..... 40 ft.
Length of space ..... 40 ft.
Ceiling height ..... 60 ft.
Ceiling color ..... Light
Wall color ..... Medium

Service requirements—general office illumination without desk lamps.

Type of the equipment—medium density opal.

Area, 40x60—3400 sq. ft.

From Table 3, 10 ft. spacing of units is the best adapted for the given ceiling height and dimensions of the space considered.

From Table 4 constant for medium density opal with light ceiling and medium walls—.235 watts per sq. ft. required to produce one foot candle illumination.

From Table 2 intensity required for office purposes under the conditions named is 4.0 foot candles.

Number of units—24.

Area per unit—100 sq. ft.

Intensity value x constant—watts per sq. ft.

4.0 x .235—.94 watts per sq. ft.

Depreciation, 15 per cent.

.94 x 1.15—1.02 watts per square foot to be provided.

1.08 x 100—108. watts per outlet.

As an example of the use of other types of incandescent units if it were desirable to use candelabra carbon lamps reference to Table 1 shows that the 100 watt value obtained when using tungsten lamps must be multiplied by a constant tabulated in the last column, namely 3.10 from which it is evident that to obtain the same illumination results it is necessary to use 310 watts in the lamps designated.

The steps to be taken in planning a lighting installation should be as follows:

1. Determination in a general way the type of lighting to be used considering decorations and service required.
2. Spacing of outlets from architectural considerations.
3. Intensity required.
4. Calculation of capacity of outlets.
5. Selection of fixtures with reference to mounting height, accessories (glassware, etc.), and of general design to conform with architectural treatment of buildings.
6. Wiring installation.

What will be the advantage of this method? First—the lighting installation will be made a part of the general design and not have the appearance of being an afterthought. It will become a means of accentuating the architectural features. The ideas of the designer will be brought out by artificial light as well as by daylight. Second—the installation cost will be practically fixed, without "extras," and explanations to the client as to the over running of the electrical appropriation. Lastly: There will be greater satisfaction to all.

It is to be remembered that the plan of procedure indicated in this paper is not given as a set of hard and fast rules, but rather as a suggestive method to be used as a basis of design. Also that the mere fact of obtaining a certain intensity value on the working plane does not constitute all the necessary considerations in planning.

One system may be suitable for some certain class of service which would be very much out of place in another. The scope of this paper does not permit any discussion of this phase of the subject as it is impossible to lay down any general rules which cover all cases. It is hoped that each individual case be given special study and that a general betterment of conditions of artificial illumination will result.

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### CAN YOU ANSWER THESE QUESTIONS?

*(Your answers to these questions submitted by readers would prove of value if published. Your viewpoint would be appreciated. You are also invited to submit your own lighting problems for solution through this same channel.)*

**My questions are based on the material set forth in "The Lighting Book," by F. Laurent Godinez.**

**1. In a living room 14x20 ft. that has thrown across one end and back again part way of one side a glass enclosed porch 8x24 ft., and 10x10 ft. at one end, would it be practicable to have a lattice ceiling above which are concealed two 40-watt tungsten lamps shaded by the gelatine films that Godinez recommends, this overhead lighting to be independent of several reading lamps?**

**2. Where can I secure the gelatine film used in theatrical lighting?**

**3. Is there any one in San Francisco who makes plaster articles like an art lamp with plaster column and capital, such as Godinez illustrates on page 102, and says on page 99 that such plaster effects are inexpensive, and that a small glass dome of mottled glass to surmount the column may be had for $1.00?**

**The room in question is in a semi-bungalow or cottage, and I wish to try these new lighting effects. The cottage is to be built up country, and the lighting company would probably oversee the wiring, and might, of course, be able to answer these questions, but from long experience, I find that one does not get information concerning such innovations in a valley town.**

**Z. L. L.**

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**The result of frosting lamp bulbs** is to appreciably decrease the useful life, but is justifiable where "bare" lamps are used, as is often the case in artistic installations. Frosting increases the end-on candlepower, but the total flux of the lamp is reduced approximately 7 per cent. The total hours or actual life of the lamp is not greatly reduced.

## NIFTY LESSONS IN SALESMANSHIP.

BY W. L. GOODWIN.

*(Upon urgent request this article together with a paper on "An Analysis of Salesmanship and Training of Salesmen as applied to the Electric Supply Business,"—which appeared in this journal for May 31, 1913,—were presented by Mr. Goodwin, vice-president Pacific States Electric Company, at a recent meeting of the San Francisco Electrical Development and Jovian League.—The Editors.)*

### Getting the Order by the "Do and Don't Route."

I will, in this paper, endeavor to give you a few "Nifty Lessons in Salesmanship," will not treat the subject as a science, but rather take you from the "sublime to the ridiculous," but, nevertheless, hope that by comparison with previous ideas, ridicule, or any other manner extract from these lines a few Do's and Don'ts, which will help you in your endeavor to fatten your pay envelope and reduce the net earnings of the company.

I will show you how to approach the most fractious customer, bridle his attention, harness his interest and lasso his order; how to open and close a sample case scientifically and carry it with one hand, how to board and unboard trains, how to register at a hotel so as to draw a room big enough to peel off a union suit without spraining the wallpaper, how to make 27 towns a day without hurrying, how to put an automobile in your expense account without even the gasolene smelling, how to come in smiling after a turndown and make the Dear Firm laugh merrily and tell you what a good fellow and fine salesman you are when you haven't sold a bill of goods in six months.

I think I am qualified to show you all these things. For the past seven years I have traveled the whole of Marin county, on the main line from Sausalito to Camp Meeker, have also walked the ties from Camp Meeker to Monte Rio and made many side trips in addition. I have stayed awake nights figuring expenses in an endeavor to balance an expense account of a Camp comprised of friends and relatives in order to strike a balance that would pass muster of all, my wife included.

In covering this great expanse of territory I have had an experience, have been able to observe, and gained an insight into the psychology of Salesmanship that few men on the road never get next to.

Those of you who are blessed with the good fortune never to have slept out nights or in railroad depots, who are without previous road experience, should be enabled with these few suggestions to sell electrical supplies as easy as it is to sell whisky in a dry town.

Thousands of my former associates in the Sales Department of the eleven hundred companies I have represented are now balancing themselves on the apex of success without parachute or pole. They are stars in the firmament of commerce, sparklers on the shirt front of the electrical industry, and so on as far as you like.

One of my students is now at the head of one of our largest electric trucks. He's delivering the goods to our customers right along. Another has opened the largest retail electrical store in San Francisco. He's been opening it every morning for the past year also the windows. And many others meeting with similar success. In fact, we have in our own organization, good paying sales positions standing around getting bow-legged, waiting for competent men to come and get them.

The thing is to become a millionaire and say what you please. It is hoped these "Nifty Lessons in Salesmanship" will make you one. As one formerly in the Sales Department wrote me. "I followed your advice, got everything in sight and now have a steady job, without traveling. Yours No. 1450."

I will now endeavor to point out how to sandbag an order without killing it, and if my advise is adhered to, success will follow on all fours.

Many salesmen think that all you need on the road is ability. Wrong! You've got to have something to sell, some definite tangible line of goods.

You couldn't expect a buyer to look over samples of nothing in particular and besides, it is difficult for a salesman to formulate a selling talk on something that wasn't anything but a bunch of nothing. Just picture yourself selling the vacuum in a Mazda lamp.

If the buyer should happen to ask at the end of a two hours' hot selling talk what your line was, it would be embarrassing to have to reply that you did not know. You might lose the sale if you made such a break.

Therefore, you must have something to sell, and it must be a line suitable to the trade you call on. You can't sell ice cream at the North Pole any more than you can sell hot coffee at the equator.

Before starting out you should know something about your line and not leave it to your customer to explain it to you. If you are selling sockets for instance, you should know which end to screw the lamp into. You also should know a socket from an arc lamp. I well remember a certain salesman who was trying to sell weatherproof wire. After he had been on the road for several months he called on me. I asked him what other kinds of wire his company made. He replied without a moment's hesitation: "Why, all kinds of course." The facts were they only made weatherproof, office and magnet wire. He didn't get the order. The company ceased manufacturing shortly after, and no doubt the calibre of their selling force had something to do with it.

The moral of this, of course, is know what you are selling and be able to side-step trouble without breaking your back.

The next thing to know is how to approach your customer, or your "prospect," as he is often called, no matter how slim a prospect he may be. The approach may be said to be the arc lamp hanger of the sale. Much depends upon it.

A weak approach, like a weak lamp hanger may mean the loss of something.

The approach must be made in such a way that your customer does not hide in the waste basket or hang out the "Too busy" sign. Always call at your customers' office or place of business when you want to sell him. Don't call at his home, nor try to interview him during church service or while he is back of the house chasing butterflies.

Many salesmen dislike to break into their prospect's office while he is busy reading the morning

newspaper or amputating a hang nail, but this should not deter you. If you were to come around again you might find he had gone to the ballgame with your competitor. Such is the daily drudge of the tired business man.

Always enter your customer's store or place of business through the door, not the transom or the chimney. The front door is generally used for this purpose and a little experience will show you how to tell it from an automobile.

Do not walk up and down in front of the store a dozen times before making up your mind to enter.

Make up your mind before you get on the premises and then march right up and open the door in a determined, business like manner, closing it firmly after you. The way the door is opened and closed indicates character.

A near salesman once wrote in for instructions on how to open and close doors. I wrote to him, giving what I thought full information. He wrote back saying that the first place he visited they had revolving doors. He didn't know how to work them and he couldn't get in, so he lost the sale, and then lost his job for losing the sale.

Once inside drop your sample case back of something so they won't know what you are. It's better to be taken for anything than a salesman. You get waited on sooner. If you are not carrying a sample case you need not be so particular.

**The Getaway.**

The next thing to do is to find out if your man is at home. There is no use trying to talk to him if he is not there.

The best way to find out is to ask somebody. Don't go rummaging through the desk drawers or looking under the table. Ask some employe of the place. If the employe says the boss is out, turn him around and look at the back of his neck. You can ascertain in this way if he is lying. I don't know how you can tell, but you can.

If your customer is really away and won't be back for a couple of months, it wouldn't be advisable to sit around the place waiting for him to return.

I knew of a salesman one time who sat around a store every day for a month, waiting for Mr. Souse of the firm of Souse & Company. All of a sudden it occurred to him that he would inquire just when Mr. Souse would return. Approaching a clerk with the question, "would you mind telling me just when you expect Mr. Souse back?" "We don't expect Mr. Souse back at all," replied the clerk calmly. He's been dead for twenty years. The business is merely run under his name.

You see, therefore, it is not only necessary to find out if your customer is away, but also when he is expected back, if at all.

Finding your man at home, however, changes the situation. The thing to do then is to discover the best way to make him stand still long enough for you to get up close to him. When you get up close to him, cough twice. That will attract his attention. Then throw your hat on his desk, followed by your card if you have one. If you have and it contains your name, that is all you need. A card with the name of the firm, your photograph, age, and family record, is not necessary.

I assume by this time you have got your customer's attention and the thing to do now is to hold it. If you haven't got his attention, you might as well talk to the stars. The only salesman who can talk his line when his customer isn't listening is the insurance solicitor. He's got his talk down so fine that he doesn't even listen to himself.

Attention is secured through one or more of five senses. Some salesmen show their samples when their customer is not looking. They expect him to hear the samples. Others talk when their man is not listening, expecting him to smell the conversation. This last can't be done unless you are using pretty strong language. The nifty salesman will soon discover which of the five senses to appeal to in order to command attention.

Some salesmen find the sense of sight a short cut to attention. Some salesmen can attract attention by doing sleight-of-hand tricks with an ordinary tomato. The customer, at first indifferent, soon finds himself fascinated and guessing for all he's worth where the juicy tomato has vanished to.

It's up your sleeve he says excitedly. "That's where you're wrong," replies the salesman; "you are sitting on it." Now, the question is—did he get his attention?

To get attention you must know what you are selling and what you are going to say. If your memory is bad, put your selling talk in writing. When you start to read your paper, he will be so surprised that he is bound to be attentive.

Interest is stretched attention.

Be sure your selling talk covers the merits of your goods. If they haven't any merit, invent some. Never run down your goods. Your competitor will do that. Should it so happen that you cannot think of any good things to say about your goods, ask your customer if he can think of any.

Or, you can excuse yourself for a few days while you write to the house for some dope.

The able salesman, however, will think up a million reasons why his customer should buy. He'll fill the air with arguments. In this way, you get the bug of desire into your customers' system. Desire is the third verse in the "Song of the Sale." You must make your customer long for your goods. Tell him what a darn fool he'll be if he doesn't buy, call him any name he'll stand for. Tell him how you sold a million dollars worth of goods yesterday. If at any time your customer shows slight signs of weariness such as yawning or falling asleep, arouse him with a left uppercut. If he laughs so long that you suspect he's purposely delaying the sale, tell him you didn't come to see him make a fool of himself, and to sit up and behave.

Once get your customer taking orders from you like that, and you'll have him where you can take an order from him.

**Desire.**

Having finally thrown the halter of Desire over the head of your customer, you now lead him gently up to the trough Resolve.

A "Resolve to buy" is the connecting link between the near sale and the sale. No matter how delirious with admiration your customer may be over your goods, if you can't bring him too long enough to have him make some coherent statement to the effect that he will Buy some of your stuff, you are a class Z Rum Salesman.

Right here, nevertheless, is where many salesmen go to the mat. They are able to coax their victim right up close to the trap where he can sniff the cheese, but they can't get him to sink a tooth into it. They lack judgment, slipping over a syllable too much, or a syllable too little.

I once lost an order for two carloads of socket bushings by excusing myself at the psychological moment, taking up the customer's telephone, to find out who won a prize fight. I afterwards learned my customer was a deacon in a church.

Sometimes when your customer stands hesitant upon the point of decision, just a gentle shove is needed to send him over the line of Desire into the safe territory of Resolve; but many salesmen think they are out with a football squad and they shove him over on his ear and he gets up red and sore.

The keen salesman should know the psychological moment, and not expect it to come out and cough, sneeze, wave its arms or give other nervous evidence of its presence. Psychological moments never do that. To get the order signed is the delicate operation. The very instant you flash your order pad, a strange something comes between you and your man. You can't see it but you can feel it. It is as thick as a wall around a penitentiary. Up to that time, all may have been like a still moonlight night on a lake, but at the sight of that order pad a storm rises from a clear sky. For that reason the order pad should be introduced without any accompanying brass band. Don't whip it out of your pocket as if you were pulling a gun. It's bad enough. Call your customer's attention to something on the ceiling, or tell him to close his eyes a moment, or look out of the window. While he is falling for it, flash the pad and begin filling in name, date, terms, etc.

Before he has time to head you off, ask him if two carloads would be too many and when he says "My-God-yes," then put down the number that he thinks will be about right. When you have written down everything that your customer needs and a lot that he doesn't need, and never will need, then ask him in a courteous way to please sign his name on the dotted line. Be sure he signs on the dotted line. Otherwise the treasurer would not know his signature from yours.

If he becomes suspicious about signing the order, assure him that everything is on the level by showing him our rating, pictures of our new building, with which every salesman should provide himself at his own expense, initials in your hat or on your linen, etc.

If it is an installment sale and you happen, by accident, to have the necessary contract form wih you, even though it may appear to him to be a mile long, and done in knotty legal terms, all about heirs, executors and legatees, explain to him very carefully that the contract really doesn't mean anything, that it is only made out in that way so the firm can hang him in case he doesn't pay for the goods. If you do not reassure him in this way, he will be afraid that when he signs the contract for a few washing machines for instance, he is signing away the old homestead, and he will get so webbed up in reading the 49 clauses of the contract that he won't know whether he is the party of the first part or the party of the second part or merely the goat.

And as it is a cinch that you yourself don't know, by all means enlighten him.

Now, then, when you finally succeed in getting the order signed—Beat it—Beat it—Beat it. Don't give him time to cut it down or change his mind. You came for that order. You got it. Beat it. Don't grab your hat and run or he will suspect you have pinched his overcoat or umbrella. Merely shake his hand warmly and go. Don't be too joyous, or he'll think it's the first order our house ever landed.

If your customer is of dignified bearing or otherwise afflicted it is well to leave him some little word of respect and good cheer such as "Good luck to you, old sport, behave yourself," or something like that. It helps cement friendships, and makes him feel easy about the order he was chump enough to give you when he really didn't need anything.

When you are once out of sight, go into the nearest saloon, ask yourself politely to have a drink and a big black Havana, twenty-five straight.

Then charge up two dollars in your expense account for a lunch. It's worth it.

The boss is a boob anyhow and he won't know. He can't tell the difference between a phoney item in an expense account and a mercury arc rectifier. Didn't I get the order. What more does he want. Brown spent thirty cents last week and I am not going to thrown Brown down. Suppose the boss does kick. The house is losing money anyhow and besides what is two dollars. Didn't I make four dollars profit on the order and ain't I entitled to half, or better still, charge it up to Pullman. There never was a Pullman on the line you travel on, but two dollars looks good to me so I might as well make the bluff anyhow.

But the main thing to remember boys, is to get the order, and do it without charging the house with the two dollars you didn't spend.

And so, I wish good luck to all of you. I hope these few suggestions on "Nifty Salesmanship" will help you in your daily grind.

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**Nitrogen Filled Lamps for Street Lighting** have been adopted by Seattle, Washington, which is the first city to adopt this new lamp for ornamental street lighting. A number of 80 c.p., 6.6 ampere type lamps have been installed on standard five-lamp posts, the lamps being fed from individual 250-watt transformers in each pole base. These transformers take current from the 120-volt mains and deliver it at eight volts to the lamps. It is expected eventually to replace all the old-type tungsten lamps in Seattle by the new nitrogen-filled units. The new lamps were shipped to Seattle from the factories of the National Quality Division of the General Electric Company.

## WATER POWER SUIT.

The Beaver River Power Company and L. L. Nunn of Utah have been made co-defendants in a suit in equity instituted by the Government on grounds similar to those which formed the basis of the suit still pending against the Utah Power and Light Company.

The action involves the right of the power company to occupy and hold possession of lands within a national forest reserve for the development and transmission of hydroelectric power without having obtained permission from the Interior Department and the payment of a rental.

It is alleged that since July, 1911, the defendants have engaged in the operation of hydroelectric power works located on what is now designated as the Fillmore National Forest without having secured permission from the Government to do so. Its existence on the land is alleged to be a trespass.

The complaint asks that the defendant be required to secure permission for the possession of the lands and also to reimburse the Government for a reasonable amount of rental during the period of the past occupancy.

The case opens up the whole subject of Federal and State control of the public domain. The power companies hold that they are entitled to the lands under the Federal act of 1866, while the Government contends that the provisions of this act, which provided for the occupancy of the public domain for power sites, were repealed by implication contained in the later Federal act of 1896, which laid down regulations by which easements for limited terms of years could be secured.

Teh first case to be brought under the Government's construction of the law governing such power sites on the public domain was that against the Utah Power and Light Company. The decision rendered in the local United States District Court was in favor of the defendant company, but on an appeal to the United States Circuit Court of Appeals, the decision of the lower court was reversed last October. The case is still pending on a motion for a re-hearing before the Court of Appeals.

The case was filed for the government by W. W. Ray, just appointed District Attorney.

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## ELECTRIC LIGHT AND POWER IN CALIFORNIA.

Preliminary figures of the forthcoming quinquennial report on the central electric light and power stations of the state of California have been given out by Director W. J. Harris of the Bureau of the Census, Department of Commerce. They were prepared under the supervision of W. M. Steuart, chief statistician for manufactures.

The statistics relate to the years ending December 31 for 1912 and 1907, and June 30 for 1902, and cover both commercial and municipal electric plants. They do not include electric plants operated by mining companies, factories, hotels, etc., which consume the current generated, those operated by the Federal government and state institutions, or plants that were idle or in course of construction.

The figures as presented for California show substantial gains for the decade 1902-1912. The number of establishments showed a slight decrease, being 112 in 1912 as compared with 115 for 1902. The total income for 1912 was $27,685,573 as compared with $5,066,417 in 1902, or an increase of 447 per cent. The total expenses for 1912 were $22,803,526 as compared with $3,918,975 in 1902, or an increase of 482 per cent. The total number of persons employed was 5738 in 1912 as compared with 1360 in 1902, or an increase of 322 per cent. The total horsepower of the engines was 416,186 in 1912 as compared with 55,855 in 1902, or an increase of 645 per cent. The horsepower of the water wheels was 432,062 in 1912 as compared with 78,933 in 1902, or an increase of 447 per cent. The output of stations amounted to 1,747,459,041 kilowatt hours in 1912 as compared with 152,728,042 in 1902, or an increase of 1044 per cent. The estimated number of arc lamps wired for service was 24,890 in 1912 as compared with 15,764 in 1902, or an increase of 58 per cent. The number of all other varieties of lamps wired for service was 6,793,200 in 1912 as compared with 1,006,875 in 1902, or an increase of 575 per cent. The horsepower capacity of the stationary motors served with electric current amounted to 603,742 in 1912 as compared with 50,296 in 1902, or an increase of 1100 per cent.

The figures are shown in detail in the accompanying table:

| California. | 1912. | 1907 | 1902. | Per cent of increase:[1] 1902-1912. |
|---|---|---|---|---|
| Number of establishments | 112 | 129 | 115 | —2.6 |
| Commercial | 97 | 115 | 105 | —7.6 |
| Municipal | 15 | 14 | 10 | 50.0 |
| Income[2] | $27,685,573 | $14,416,529 | $5,066,417 | 446.5 |
| Light, heat and power | $26,461,154 | $13,922,028 | $4,946,090 | 435.0 |
| All other sources | $1,224,419 | $494,501 | $120,327 | 917.6 |
| Total expenses, including salaries and wages | $22,803,526 | $12,580,937 | $3,918,975 | 481.9 |
| Total number of persons employed | 5,738 | 3,128 | 1,360 | 321.9 |
| Total horsepower | 848,248 | 384,673 | 134,788 | 529.3 |
| Steam and gas engines (including turbines)— | | | | |
| Number | 180 | 167 | 156 | 15.4 |
| Horsepower | 416,186 | 149,884 | 54,843 | 658.9 |
| Water wheels— | | | | |
| Number | 205 | 172 | 133 | 54.1 |
| Horsepower | 432,062 | 208,444 | 78,933 | 447.4 |
| Auxiliary engines: | | | | |
| Number | [3] | 45 | 44 | ..... |
| Horsepower | [3] | 26,345 | 1,012 | ..... |
| Kilowatt capacity of dynamos | 588,281 | 238,480 | 83,816 | 601.9 |
| Output of stations, kilowatt hours | 1,747,459,041 | 661,606,309 | 152,728,042 | 1,044.2 |
| Estimated number of lamps wired for service: | | | | |
| Arc | 24,890 | [4] 19,691 | 15,764 | 57.9 |
| All other varieties | 6,793,200 | [4] 3,068,214 | 1,006,875 | 574.7 |
| Stationary motors served: | | | | |
| Number | 29,059 | 11,560 | 5,190 | 459.9 |
| H.P. capacity | 603,742 | 200,067 | 50,296 | 1,100.4 |

[1] A minus sign (—) denotes decrease.

[2] Exclusive of $75,817 in 1912; $366,566 in 1907; and $279,216 in 1902, reported by street and electric railway companies as income from sale of electric current for light or power, or from sale of current to other public service corporations.

[3] Not reported separately.

[4] Exclusive of 373 arc and 16,996 lamps of other varieties reported by the electric companies as used to light their own properties. Lamps used for such service were included in the number reported for 1912.

## EFFECT OF FORESTS ON RUNOFF.

BY J. C. STEVENS.

(Concluded.)

### Uniformity of Flow.

I wish to present briefly a few data on this subject, since it is the main issue so far as forestry effects are concerned. I have chosen streams in pairs, existing under the same climatic conditions, some with forest drainage areas and some without forests.

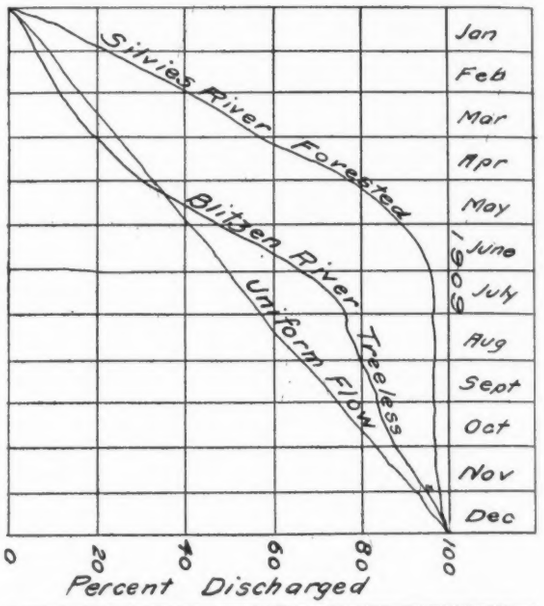
Of course, it is futile to draw conclusions or to attempts to obtain a measure of forestry effects from such comparisons; nevertheless, the causes of uniformity of flow are well worth an investigation.

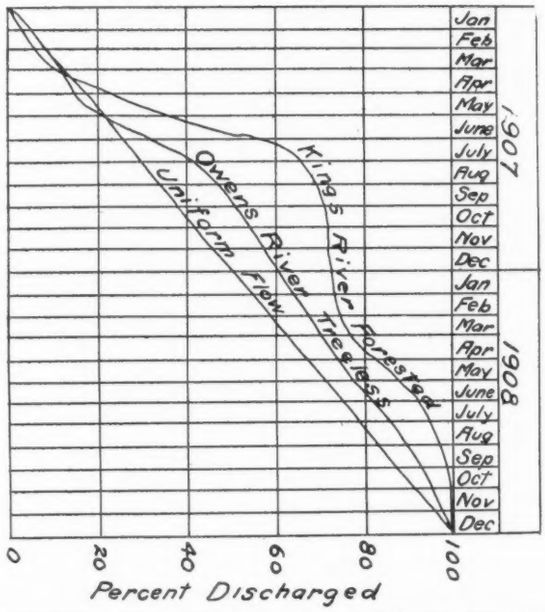
On the streams chosen, long records are not available, nor are they necessary. A comparison of simultaneous records for even one year are justifiable if the streams are subject to the same climatic influences.

The absolute values of runoff are of no moment in this inquiry, neither is a comparison of precipitation vital. To obtain a measure of uniformity of flow, a certain period has been selected, and the runoff for each month of that period has been expressed as a rainfall. Simultaneous records for 1909 have been added successively, giving a "mass curve" of monthly runoff.

Silvies and Blitzen Rivers lie in central Oregon. They flow from opposite directions into Malheur Lake. Both have about the some range of elevations. The topography is not unlike, and the soil and geologic structure are comparable. The Blitzen watershed has no trees at all, while the Silvies watershed is fairly well forested. Each receives about the same rainfall. Simultaneous records for 1902 have been used. The Blitzen River has a drainage area of 238 sq. miles, and discharged 77,100 acre ft. of water. Silvies River drains 450 sq. miles, and discharged 73,600 acre ft, in the same period.

Fig. 6 shows the uniformity characteristics of the two streams. If the flow was absolutely uniform, the curves would follow the straight line; that is, a constant percentage of the total flow would be discharged each month. The nearer the discharge curve follows and parallels this line, the more uniform is the flow. It is seen that Blitzen River without forests is very uniform, while Silvies discharged nearly all the water in the first six months of the year. (Where the curve is vertical, it indicates that nothing is being added to what has already passed.) Measured by our former standard of uniformity, i. e., the ratio of the minimum to the maximum, we find the uniformity factor for Blitzen River was .075, and of Silvies River .00079; that is, the uniformity of Blitzen River, without forests, is 100 times greater than the forested Silvies River. The principal reason for this lies in the fact that the Blitzen area is cut into gullies and canyons into which enormous quantities of snow are drifted each year. These melt gradually and keep up the flow. If the area were timbered, a great deal of this drifting would be prevented and it is not likely that so great a uniformity would obtain. Certain it is, the differences of soil and topography can never account for this great difference in flow. It is also seen that the yield per square mile of the Blitzen River is over twice that of the Silvies. The effect of dissipation



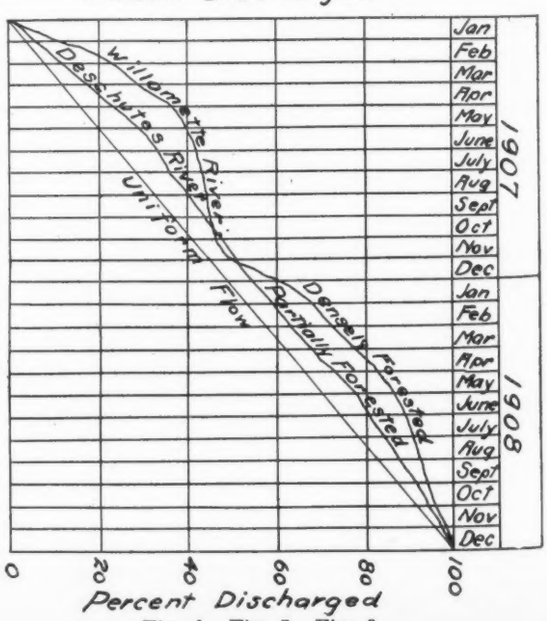




Fig. 6. Fig. 7. Fig. 8.
Giving "Mass Curves" of Monthly Runoff.

of water in this semi-arid region by forests is material in this case; however, it is doubtful if it will account for this difference in total yield.

I do not contend, by any means, that this difference in flow characteristics is accounted for by forest cover. It is due mainly to other causes. The effect of the trees in preventing snow drifts on Silvies watershed tends to decrease its uniformity of flow, but it is only a tendency, and I do not believe the absolute effect of this factor will account for more than 10 to 15 per cent of the difference in uniformity of flow.

Fig. 7 is a similar diagram for Kings and Owens rivers in California. Kings River drains 1740 square miles of densely forested mountainous country on the western slope of the Sierra Nevada Range. Owens River drains about 450 square miles of treeless country of the opposite side of the range. The general topographic and geologic features of the two regions are similar, although the Kings River watershed receives a great deal more precipitation in the year than does the Owens River Basin. The temperatures on the eastern side of the range are generally lower than those on the western.

Owens River is remarkably uniform in flow, as will be seen from the figure. The ratio of minimum to maximum during this period, 1907-8, which includes a high and a low year, was 0.146. Kings River, on the other hand, is subject to enormous floods and the minimum flow is comparatively low. Its ratio of minimum to maximum during the same period was only .0163. That is, the uniformity of Owens River is ten times that of Kings River.

This difference is decidedly unfavorable to the forest theory. However, we must look elsewhere for the explanation. The soil porosity and underlying rocks and the ruggedness of topography are similar on the two areas. The cause of the difference is found in the differences of temperature and precipitation. The flow of Owens River is maintained during the summer by huge snowdrifts that accumulate in the gullies and canyons of its area. The process of drifting is not interfered with by a forest cover. This interference, although a minor factor, is not immaterial.

We will next compare two forested watersheds. Willamette and Deschutes Rivers of Oregon, both flowing north, parallel to the Cascade Range; Willamette River drains 4860 square miles on the west, Deschutes River drains 9180 square miles on the east. The Willamette watershed is densely forested, while the Deschutes is only partially so. The topography of the area does not differ greatly, but the overlying soils are radically different.

Deschutes River is remarkably uniform in flow. Willamette River has no such distinction. The years 1907-8 include both a high- and a low-water year. The uniformity ratio of Deschutes River during this period was .180, while that of the Willamette was only .014, less than one-eighth as large. Fig. 8 shows the uniformity diagram for these streams, from which the wonderful uniformity in the flow of Deschutes River is apparent.

The difference in uniformity of flow of these streams is not due to forestry effects, for the less uniform stream has fully double the extent and density of forest cover. The cause is found in the soil cover and underlying rock structure. The Deschutes area is covered with a thick layer of porous pumiceous soil, presumably blown eastward by prevailing winds during the early periods of volcanic activity. Under this pumiceous cover lies the porous lava rocks. Together they provide such an abundant ground storage that the flow of Deschutes River scarcely varies from season to season. Whatever effect the forest has is to prevent soil absorption. The forest humus is less porous than the soil and therefore tends to prevent water from filtering into the soil. If we cover a pile of sand with fine dust, the dust acts as a shield to prevent infiltration.

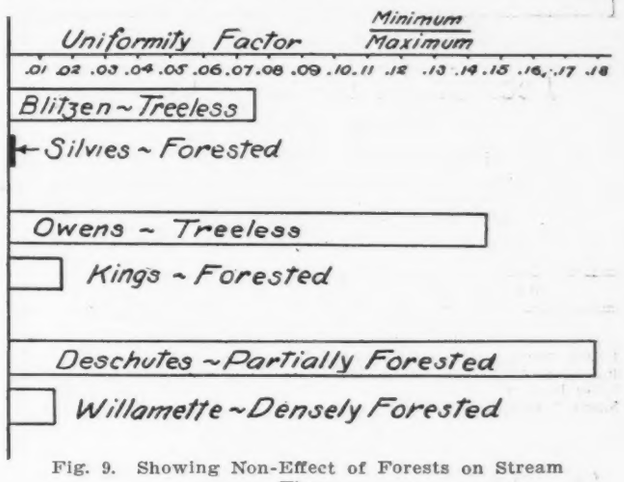

Uniformity Factor
Minimum
Maximum
.01 .02 .03 .04 .05 .06 .07 .08 .09 .10 .11 .12 .13 .14 .15 .16 .17 .18
Blitzen ~ Treeless
Silvies ~ Forested
Owens ~ Treeless
Kings ~ Forested
Deschutes ~ Partially Forested
Willamette ~ Densely Forested

Fig. 9. Showing Non-Effect of Forests on Stream Flow.

On the Willamette watershed the soil is finer and more compact. The capacity for general storage is not nearly so great as on the Deschutes area. The forest cover, if it has any effect at all on this watershed, probably has a tendency to aid infiltration. This effect, however, is more than offset by the mechanical interference of the forests with snow drifting. The final result would probably be a slightly greater uniformity in both streams if the forests were removed. The difference, however, would be too slight to be of any importance.

The foregoing examples show conclusively that uniformity of stream flow is influenced, practically in total, by factors entirely independent of forests, and if forests have any influence at all on this feature, it is very insignificant. The tendency they do possess, though almost infinitesimal, would be in a helpful direction in some cases, in others in a harmful direction.

In order to sum up concretely the essential facts as brought out under this caption, I have prepared Fig. 9. The uniformity factors (ratio of minimum to maximum) for the examples cited, are shown to scale. Remembering that the larger this ratio, the more uniform the flow, the diagram needs no further explanation.

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**The latent heat of fusion of ice** as determined from a most careful series of experiments of the U. S. Bureau of Standards is 79.63 calories per gram mass or 143.3 B.t.u. per pound mass.

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POWER AND GAS

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## CONTENTS


The Interpretation of Electric Current Flow in Terms of the Electron Theory ..... 175
*By W. F. Durand.*

Normal Wet Concreter Carrying Currents ..... 180

Generating Steam Electrically ..... 181

A Bill to Aid Hydroelectric Development ..... 181

The Largest System of Electric Railways in Canada ..... 182

Lighting Effects With Gas and Steam ..... 183
*By Waldemar H. F. N. De Bille.*

Planning Lighting Installations ..... 184
*By J. B. Jackson.*

Can You Answer These Questions ..... 185

The Result of Frosting Lamp Bulbs ..... 185

Nifty Lessons in Salesmanship ..... 186
*By W. L. Goodwin.*

Nitrogen Filled Lamps for Street Lighting ..... 188

Water Power Suit ..... 189

Electric Light and Power in California ..... 189

Effect of Forests on Runoff ..... 190
*By J. C. Stevens.*

The Latent Heat of Fusion of Ice ..... 191

Editorial ..... 192
Visualizing Electricity.
On Being a Joiner.
Exposition Lighting 1915.

Personals ..... 194

Meeting Notices ..... 194

Trade Notes ..... 195

New Catalogues ..... 195

News Notes ..... 196


**Visualizing Electricity**

The real nature of electricity was the great unanswered riddle of the nineteenth century. The layman regarded it as an inexplicable mystery, the engineer was content to know the laws of its action and control, but the inquisitive scientist persisted in trying to discover its ultimate nature. So each year of the twentieth century has brought forth some discovery or some new idea which makes possible an ever bolder statement and an ever clearer mental picture as to what electricity is.

The several forms of radiant energy, electric waves, Hertzian waves, light rays and X-rays, have all been shown to be transversal wave motions transmitted through a hypothetical medium known as the ether. While the existence of this ether cannot be detected by the limitations of any of the five human senses, we have every reason to believe that it fills all space and permeates all matter.

Meanwhile the biologist has found that the form of any object is a diagram of forces, the shape of matter being due to the action of energy. The chemist found that matter is made up of extremely small particles known as molecules, which are in a continuous state of motion. These molecules are aggregates of two or more atoms, which in turn are largely made up of positive and negative electric charges known as ions or electrons, their number and their arrangement determining the kind of element.

Thus each infinitesimal atom may be imagined as a solar system which is held together by the mutual attraction of a central positive nucleus, and surrounding negative satellites. While the satellites revolve about the central sun the entire system has no velocity relative to the universe, of which it is an infinitesimal part. But there are negative electrons which, like comets, circulate from one system to another, thus establishing an exchange of energy between distant systems.

This electronic theory of energy assumes reality and gains in probability as it accounts for more and more new facts. It pictures matter as made up of fixed positive and neutral atoms and free negative electrons ready to respond to some accelerating force, and thus carry this energy to another system. While the negative electrons in an electric insulator, such as glass, do not respond to the accelerating action of electric force, they are affected by light waves, and thus act as carriers of light energy. On the other hand, the negative electrons of an electric conductor respond to an electric force, but not to light, and thus act as carriers of electric energy.

As this theory expresses matter in terms of electric charges, and the ether and as one form of energy can be changed into another, it should be possible to express electrical concepts in terms of mechanics, physics or chemistry, and so give a better understanding of electric phenomena in terms with which all are familiar.

Elsewhere in this issue W. F. Durand, Professor of Mechanical Engineering at Stanford University, by means of a beautiful physical explanation, identifies the heating effect in the conductor with the loss of energy by the free electrons. He shows that the rate

of work is proportional to their kinetic energy, that current flow is measured by their group momentum, and that all other specifications of an electric circuit can be expressed in terms of the number of electrons per unit area, the time during which they act, and the size and length of the conductor.

The engineer is more accustomed to thinking in these physical terms than in the mathematical abstractions by which electricity is usually expressed. Mathematics is a language which all cannot translate into English, and to the non-mathematician the mystery of electricity is still further dimmed by the obscurities of the calculus. Professor Durand's method is consequently a classic contribution to the great problem of visualizing electricity.

---

**On Being a Joiner**

Engineering and industrial societies are multiplying so rapidly that the surface appearance is that many must be unnecessary. That this is not so is borne out by the fact that each one arises in answer to a need, and is more directly the outgrowth of an age of specialization. Whenever one society alone has attempted to handle the technical, commercial, legal and other aspects of a particular line of endeavor, its work has become unwieldy.

But a comparatively short while ago, it was considered a sign of weakness to combine with others for mutual benefit in business. To be a "joiner" demonstrated lack of self reliance. Comparisons were then made between the sheep and the lion. You were weak to join, strong to stand alone. Views are now to the contrary.

Joint operation—working together for mutual benefit—is the keynote of the times.

In each society individual membership involves certain responsibilities. It is not only for what you will gain but for what you can give, that membership should be sought.

When asked to join any society one is apt to analyze the prospectus too closely for individual benefits of direct application. The general educational value of the work of a society both to the layman and professionals, will undoubtedly result in increased business. This may be due either to finding new outlets for trade or in raising standards of work so that better business obtains.

Active interest is most to be desired, but inability to attend meetings is not sufficient excuse for non-membership. Each should recognize that he owes practically everything to those pioneers and investigators who have gone before, and to those with whom he now labors, or, in a word, to his business.

Yet there are those who fail to recognize this debt, those who think themselves only responsible for the knowledge they possess. They desire to hoard it for personal privilege and private gain.

As a matter of fact, it belongs to all.

Each must do his part it is true, but the work you do contains nothing of isolation for into the lives of all men everywhere, has mounted up their debt to the past, and to contemporary thought and endeavor.

Realization of this fact would make the most pronounced egoist desirous of reaching out after opportunities to repay in degree their debt to that other part of existence so vaster than one's self.

Maurice Maeterlinck says of the bees, that they manifest a great common duty impartially distributed amongst them all and tending towards a future that goes farther and farther back ever since the world began. For the sake of the future, each bee renounces more than half of joy.

No such sacrifices are asked of the prospective "joiner," although it must be recognized that the increasing memberships possible, especially to electrical men, represents to the average individual an altogether too heavy financial burden.

What to join?

This question can perhaps be best answered by a reference to duty—duty to self, to one's fellows, to business, and to society at large, and its consideration may urge not only membership in additional societies, but a prompt renewal of those annual dues which have already been outstanding overly long.

---

**Exposition Lighting 1915**

Victor Hugo writes of French peasants who in a certain district were so poor that for artificial light, they burned resinous sticks and pieces of rope dipped in pitch. This was in 1815. The clock that ticks off the centuries has swung far over until it poises almost again at the starting point. The farmer of today uses the now common electric light.

But as in 1815 there were many systems of lighting in advance of the reeking and smoky burning rope, so there are now systems of lighting superior to those commonly used.

At the Panama-Pacific International Exposition at San Francisco, 1915, many of these will be in evidence.

From the former appeal of the "White City" to the moth instinct in man, a progressive appeal is now to be made to his sense of the esthetic. There will be no bright lights, but a symphony of color consequent upon scientifically applied light.

The capacity of visitors for seeing will be enhanced by this considerateness. The pain of burning eyeballs will not there tire, for even the "pyrotechnics" will be robbed of their intensely heated particles of high intrinsic brilliancy. Balls of fire will not burn their impress, like a branding iron, into the brain. Seeing will be as comfortable as modern travel.

Light playing upon smoke and steam, soap bubbles, and balls of cloth, will produce the more pleasing and more effective "fireworks."

But to say that there will be no brilliant light is not entirely correct, and savors of describing the diamond in terms of the moonstone, for thousands of jewels, more beautiful than the most magnificent gems, will scintillate bright rays of vari-colored lights from the outlined towers and buildings on which they are used.

Correct and spectacular high-pressure gas lighting will also be seen.

Those who have advocated outdoor indirect lighting will witness the achievement of this much to be desired end. The entire system will be what it should —an exposition of the utmost advance in the lighting art.

"There will be no night there neither sorrow nor sighing," for truly, the former things, have been done away.

# PERSONALS

ITEMS FOR THIS DEPARTMENT ARE SOLICITED FROM ALL READERS

**Chas. W. Barker,** district engineer, Westinghouse Machine Company, is at San Francisco.

**H. W. Beecher,** manager Seattle office, Chas. C. Moore & Company Engineers, is a visitor at San Francisco.

**W. H. Leffingwell,** chief engineer, Mono Power Company, Bishop Creek, Cal., was in San Francisco this week.

**F. L. Pratt,** vice-president, Stone & Webster Corporation, Boston, Mass., was at Seattle during the past week.

**C. H. Holley,** secretary and manager, Tulare County Power Company, Lindsay, Cal.. was at San Francisco last week.

**Henry E. Harris,** of the Harris Ice Machine Company, Portland, Oregon, was a recent visitor at San Francisco.

**Bassett Jones Jr.,** electrical and illuminating engineer, is now associated with the H. W. Johns-Manville Company.

**W. P. Ballard,** superintendent Visalia Electric Railway, Exeter, Cal., was a visitor at San Francisco during the past week.

**J. W. Thompson,** salesman, electrical department, H. W. Johns-Manville Company, has returned to San Francisco from New York.

**H. L. Jackman,** manager, Western States Gas & Electric Company, was at San Francisco from Eureka during the past week.

**E. N. Sanderson,** of Sanderson & Porter, consulting engineers, is now at Tucson, Arizona, and expected at San Francisco shortly.

**Armond P. Marion,** civil engineer, announces the removal of his offices from 312 Hoge Building, Seattle, to 314 Mehlhorn Building.

**Geo. A. Boomer,** Pacific Coast representative, Plume & Atwood Manufacturing Company, is on a business trip through the Pacific Northwest.

**H. B. Hall,** Pacific Coast manager, Pass & Seymour, Inc., has returned to San Francisco from a business trip made throughout the Pacific Northwest.

**W. J. C. Wakefield** has been elected chairman of the executive committee of the Washington Water Power Company, Spokane, Wash., to succeed the late Henry M. Richards.

**W. L. Overman,** representative of the Hughes Electric Heating Company, is in Salt Lake City completing arrangements for handling their line of electric ranges in that territory.

**George P. Trayner** has resigned his position in the commercial department of the Utah Light & Railway Company and has gone on the road for the Lambert Paper Company of Salt Lake City.

**H. L. Garbutt,** head of the railway line material division, Westinghouse Electric & Manufacturing Company, is at San Francisco and will visit other western offices of the company in the interests of his department.

**W. J. Grambs,** assistant to the president, Puget Sound Traction, Light & Power Company, was a recent visitor at Portland, Oregon. Mr. Grambs was recently elected treasurer of the Employers' Association of Washington.

**W. D. Thomas,** of Petaluma, Cal., has disposed of his interests in the electrical contracting business which will now be carried on by Bauer & Baugh, the purchasers. Mr. Thomas will engage in the automobile supply business at Fresno, Cal.

**T. L. Bissell** has resigned his position in the commercial department of the Utah Light & Railway Company and has taken the agency for several lines of contractors' machinery for the state of Ohio, has returned to the East to take up this line of work.

**R. Vance Pearson** has been appointed to represent the Utah Light & Railway Company in the commercial field at Ogden, Utah. Mr. Pearson has been connected with the electric line and service department of the above named company for the past ten years, in Salt Lake City and Ogden, Utah.

**Paul Lebenbaum,** electrical engineer, Portland, Eugene & Eastern Railroad, will speak on the electrification of that company's line, at the next joint meeting of the Portland Sections A. I. E. E., and N. E. L. A., at the Hawthorne Building, Portland, Oregon, March 3d.

**S. T. Whitaker,** local manager Utah Light & Railway Company, Ogden, has just returned from a two weeks' trip to California points. While the main objects of his journey were rest and recreation, Mr. Whitaker spent considerable time looking into matters pertaining to the electric light, power and gas business.

**W. E. Blodgett,** assistant secretary of the Utah Light & Railway Company, has returned from a trip to Los Angeles and San Francisco. He took occasion while there to investigate the progress in the lighting, power and street railway development, and was particularly impressed with the rural distribution systems there and the high voltage of the main transmission lines.

**W. C. Wurfdel,** district manager Westinghouse Lamp Company, Salt Lake City, presided at a get-together banquet held at the Commercial Club last week, at which twenty-two members of the local sales organization were present. **Walter Albertson,** of the Denver office of the company, and **L. Wood Davis,** covering the Butte and Spokane territory, were also in attendance.

**John H. Lewis,** state engineer, Oregon, has announced his candidacy for re-election. He was appointed to his present position by Governor Chamberlain when the office was created in 1905. His office has to do with the water resources of the state, and he conducts waterpower and other surveys in co-operation with the United States. He first suggested co-operation between the state and Nation in the construction of reclamation works in 1912, which plan is now being favorably considered by a number of states. Lewis was recently appointed by the American Society of Civil Engineers on a committee to prepare a national water law.

**Edward M. Cheney,** electrical engineer, Washington Surveying and Rating Bureau, 459 Colman Building, Seattle, Wash., has been elected an Associate Member of the American Institute of Electrical Engineers. The following have also been elected associates: **Wm. D. Cleveland,** superintendent telephone and telegraph, Oregon Electric Railway, Portland, Oregon; **Jas. G. M. Connolly,** electrician, Western Canada Power Company, Vancouver, B. C.; **E. A. Haggan,** editor, Mining, Engineering and Electrical Record, Vancouver, B. C.; **George H. Kohl,** electrical engineer, Ritchie, Agnew & Company, Prince Rupert, B. C.; **C. D. Lamoree,** sales engineer, Westinghouse Electric & Manufacturing Company, Los Angeles, Cal.; **Carl C. Long,** station superintendent, Utah Power & Light Company, Grace, Idaho; **Alfred Trott,** erecting department, Canadian Westinghouse Company, Vancouver, B. C., and **Albert L. Walker,** assistant resident engineer, Grand Trunk Pacific Railway Company, Dry Dock, Prince Rupert, B. C.

## MEETING NOTICES.

### Pacific Coast Jobbers' Association.

The next convention will be held at Del Monte, Cal., on March 5, 6 and 7, 1914. A large and representative attendance is anticipated and a comprehensive program will be carried out.

### Pacific Coast Gas Association Convention.

The 22d annual convention of this association will be held at Long Beach, California, from September 16 to 18, 1914, both dates inclusive. Some excellent papers are already re-

ceiving consideration at the hands of the authors and will prove of benefit and industry to the gas fraternity. It will pay to plan ahead to be there.

### Utah Society of Engineers.

L. C. Howard, a Salt Lake mining engineer, and editor of the Salt Lake Mining Review, gave a talk at the regular meeting of the Utah Society of Engineers, on February 20tn, on "The Development of Utah Radium Bearing Ores."

### San Francisco Electrical Development and Jovian League.

"With the Movies Through the Panama Canal," constituted a good drawing card at the regular weekly meeting of the league. Mr. E. H. Kemp made the photographic tour for the government and told, informally, much of interest in connection with the great work. The pictures also were excellent.

### Portland Electrical League Luncheon.

The regular luncheon of the Electrical League of Portland, Oregon, was held at 12:15 p. m., Wednesday, February 18th. Motion pictures of the Assouan dam in Egypt were shown. The Assouan dam is the largest dam and one of the greatest engineering projects in the world. It extends across the Nile River 700 miles above its mouth, and is 6400 ft. long. The cost of the dam was $24,000,000. The dam creates a storage reservoir 143 miles long from the flood waters of the Nile. This water is used for irrigating purposes during the dry season.

Also a film was shown depicting the new oxy-acetylene flame in action cutting steel bars.

The luncheon was attended by over 100 electrical men and their friends and pronounced a great success by every one present. Burnett Goodwin of the Northwestern Eectric Company acted as chairman. The next luncheon will be on Wednesday, March 4th, at the Multnomah Hotel.

### Cleveland Electrical Exposition.

Cleveland is planning a great electrical exposition to be held May 20 to 30 in the Coliseum. The project is to be given under the auspices of the Electrical League of Cleveland whose committees have been so active during the first month of preparation that success is already assured. The Sixth City claims to lead the nation in many departments of the electrical trade. It is the headquarters for the greatest lamp works, the home of the biggest carbon manufacturing plant, and it boasts of three leading manufacturers of electric vehicles. It holds highest rank in the manufacture of electric cranes and hoisting machinery and is a leader in the making of batteries. It claims many of the largest electrical machinery plants, and its public service company is said to be a model of progress and efficiency.

Applications for space have come so swiftly that three weeks from the date of the launching of the project, one-half of the total floor area was sold.

For its decorating and lighting scheme the committee has the services of a corps of leading electrical engineers. This is to be the first electrical exposition ever held in Cleveland, and the city is planning to give it in the same manner that characterized its Industrial Exposition which was acknowledged to be the largest and most successful ever held in this country.

### Utah Electric Club.

At the regular weekly luncheon of the Utah Electric Club held February 19th, Dr. A. A. Knowlton, Professor of Physics at the University of Utah, spoke on "The Electrical Method of Smoke Prevention." He illustrated with a small experimental model of the Cottrell system of smoke deposition which is now being applied to two of the large smelters in Salt Lake valley, and which offers to afford a fairly satisfactory solution of the problem of smoke prevention as applied to large stacks. According to his observations, much of the smoke here in Salt Lake City in the residential portion is caused by the smoke from the small stacks of residences and apartment houses in that section.

As a member of the club Dr. Knowlton offered a resolution providing that the Electric Club recommend to the commission of Salt Lake City that they employ a corps of experts to be headed by the best authority on the subject to be found in the country, to study the smoke problem as it affects this city, which resolution was unanimously adopted.

Ex-Governor Heber M. Wells, who is now Commissioner of Parks and Public Property, was present and expressed himself as favoring this move. Mr. Wells was largely responsible for the recent smoke prevention ordinances passed by the city commission. He stated that the commission had studied the ordinances with reference to this subject in all of the principal cities of the country, and after careful consideration, had adopted one patterned after the ordinance now in effect in Chicago, which seems to meet the conditions existing here as nearly as one could be drawn.

## TRADE NOTES.

The Holophane Works of General Electric Company announces a new district office in the Frisco Building, St. Louis, Mo. J. G. Barrett will be in charge of this office, with R. H. Lyon as his assistant. The Chicago district office has been transferred from 425 So. Wabash avenue to room 715 Mallers building. John W. Foster is manager of sales in the Chicago district. R. E. Perry, who has handled Holophane sales in the Cleveland district, has been transferred to the Chicago district with headquarters at Minneapolis.

A 200 h.p. steam plant on Andrus Island in the Sacramento River near Walnut Grove, California, was put out of commission when the Island was flooded on January 29th. On January 30th it was decided to put in a 150 h.p. electric driven unit to take its place. It was absolutely necessary to have this plant operating at once, as several families on the Island were in great danger. By February 2d the Great Western Power Company had set twenty-four poles, and W. S. Heger Jr. had installed a motor, and finished the connections, so that the pumps were in operation that evening. The motor was supplied by the General Electric Company, who had it en route three hours after the order was placed, and the special pulleys necessary to convert the direct driven steam unit into a belt driven electric unit, were designed, built and shipped by Meese, Gottfried Company within three days.

## NEW CATALOGUES.

The Simplex Manual issued by the Simplex Wire & Cable Company in a handy pocket size, contains, in addition to information regarding Simplex products, tables and data for ready reference and will be found invaluable to electrical engineers, contractors, wiremen and others.

A door safety switch is described in a bulletin just issued by the Cutler-Hammer Company, Milwaukee, Wis. A great majority of accidents occurring on all types of elevators are the result of setting the elevator in motion before the doors are locked. This bulletin shows how such accidents and others incidental to elevator operation may be avoided.

The Westinghouse Electric and Manufacturing Company has just issued Folder 4237, "The Way to Charge Three Cells." It describes the Westinghouse mechanical vibrating rectifier for charging small storage batteries used for ignition and lighting sets on automobiles. Westinghouse Electric Vehicle Equipment, Section 3223, shows a number of illustrations, together with detailed description of the construction of the electric motor and its application. Curves are also given showing the performance of 60 and 80-volt motors. Section DS1410 covering direct-curent switchboard panels for 100 and 220-volt systems. Section DS842 of the Trolley Line Material Catalogue lists and describes various bracket arms for direct and catenary construction.

# NEWS NOTES

## INCORPORATIONS.

SAN FRANCISCO, CAL.—Rex Electric & Construction Company, $25,000, shares $1 each, subscribed $3, by A. E. Needham, W. W. Perry and E. R. Eliassen.

BLAINE, WASH.—Blaine, Lynden Electric Company has organized with a capital stock of $250,000. The purpose is to build an interurban road between Blaine and Lynden. The officers are John J. Pinckney, president; Lester Livingston, secretary, and James A. Willson, treasurer, all of Blaine.

THREE FORKS, MONT.—The Farmers' Home Telephone Company has filed articles of incorporation for the purpose of constructing, purchasing, leasing, operating and maintaining telephone exchanges in parts of Gallatin, Broadwater and Jefferson counties. G. C. Watson, V. Lund Jr., R. S. Dutcher, R. R. Young and J. A. Gastineau are directors.

## ILLUMINATION.

ARCADIA, CAL.—Bids will be received up to April 4th for an electric franchise upon streets in this city.

BELLINGHAM, WASH.—Mayor J. P. de Mattos in special message to council recommended bonding of the city for $400,000 to build a municipal lighting plant.

RIVERBANK, CAL.—The supervisors have granted a franchise to the Oakdale Gas Company to lay gas pipes and conduits from Oakdale to Riverbank.

GLOBE, ARIZ.—Petitions are to be circulated in a short time to secure signers in favor of a bond election for construction of a municipal electric light plant.

ST. HELENA, CAL.—Sealed bids will be received up to March 10th for installing thirty-seven 3-light electroliers on Main street between Sulphur Spring Creek and York Creek.

HELENA, MONT.—Citizens of the west side have decided to petition the council for a lighting system similar to one now in use on the east side. Mayor Purcell is in favor of the petition and the council will take action in the matter soon.

SNOHOMISH, WASH.—A representative of a large corporation has been in conference with Mayor Watson regarding the possibilities of granting a second franchise for the privilege of erecting poles and wires and furnishing electric light and power in this city.

RIALTO, CAL.—Sealed bids will be received up to April 7th, by the board of trustees for franchise, granting right to construct and operate for a period of 59 years, an electric pole and wire system for transmitting electrical energy along streets in this city. The franchise has been applied for by the Rialto Light, Power & Water Company.

VANCOUVER, B. C.—For stealing current for about one year from the lines of the British Columbia Electric Railway Company, a former electrician, now a cattle dealer in the Collingwood district, was sentenced by Judge McInnes to a six months' term in jail with the option of a $500 fine and was required, in addition, to pay an estimated bill for current taken, of $241.

BOISE, IDAHO.—Pursuant to the provisions of that portion of the public utility act passed at the 1912-13 session of the Idaho state legislature, regarding the rates for electric light and power service throughout Idaho, the Utah Power & Light Company has filed with the public utilities commission of the state a new and uniform schedule of rates for all service furnished by the company to its Idaho customers. The new schedule will go into effect about March 1st, throughout all of the territory served in Idaho by the Utah Power & Light Company.

## TRANSMISSION.

TUCSON, ARIZ.—That it is commercially feasible to build a dam in Grand Canyon of Arizona and supply cheap power throughout the state has been determined by Col. Espes Randolph, president of Randolph lines. He and his associates, Ralph H. Cameron of Phoenix and Eugene S. Ives of Tucson, are looking into their legal rights. The project would cost about $44,000,000, possibly $50,000,000.

## TRANSPORTATION.

PRESCOTT, ARIZ.—The Winslow city council has voted a franchise to J. F. Mahoney to construct and operate an electric street car system.

SAN FRANCISCO, CAL.—The board of public works has given notice of a call for bids to be opened on May 4th for building the Chestnut street branch of the Municipal Street Railway system from Van Ness avenue along the Exposition grounds. This will be the first portion of the extension to be built under the recent bond issue.

SAN FRANCISCO, CAL.—The proposed construction of part of a new municipal railway line on Second avenue, between Geary and Cornwall streets, should be carried out, the city engineer has advised the supervisors, notwithstanding the protest of owners of property on the avenue, who claimed that the roadway was too narrow for a railway.

PORTLAND, ORE.—The Sandy Commercial Club has been informed that the franchise to construct a single track railway from Boring to Sandy has been granted by the Clackamas County Court to the Clackamas County Development Company. The power will be gasoline to start with but later it is expected that it will be electricity. The promoters say that they will build the line at once.

OAKLAND, CAL.—The San Ramon Valley Electric Railroad, a feeder of the Oakland, Antioch & Eastern, recently constructed at a cost of $300,000, will open for passenger and freight business March 1st. The new road joins the main line of the Oakland & Antioch one mile west of Walnut Creek and extends 11 miles southward tapping the farming districts of Danville and Alamo and extending to the foot of Mt. Diablo near the center of the Cook ranch.

BUTTE, MONT.—Butte Street Railway Company has filed a petition asking for a franchise for the construction of a line to run east on Dewey street and south on Paxton street to Cleveland street, distance of three-quarters of a mile. The estimated cost is $10,000. The construction is to be paid for by the Butte Improvement Company, incorporated by H. E. Hickey, president; H. A. Frank, secretary and treasurer; E. M. Frank, vice-president. If the franchise is granted light and telephone wires will be extended to the district.

OAKLAND, CAL.—The first elevated railway in this vicinity was opened for use last week when the Berkeley electric trains of the Southern Pacific Company were run over the elevated tracks at the Sixteenth street station. The road cost nearly $500,000 and is entirely of steel and piling. The new elevated structure is used by trains of the Shattuck avenue, Ellsworth avenue, California street loop and Ninth street loop. The new structure is about a mile long, running from Ninth to Twentieth streets. It is double tracked and rock ballasted.

SALT LAKE CITY, UTAH.—The Utah Light & Railway Company, announces that the extension of the Holliday street railway line from its present terminus approximately ten miles southeast from the center of the city through to the company's lower power house in Cottonwood Canyon, a dis-

tance of approximately five miles will be built. The Big Cottonwood Canyon is one of the most picturesque of Utah's canyons and has long been popular as a summer camping place. It has not been readily accessible to tourists heretofore, except by automobile stages, and this extension should develop a large amount of traffic there, both in summer and winter.

SAN FRANCISCO, CAL.—The Ocean Shore Railroad will probably be operated by electricity within a few months. Land operators and investors have pledged themselves to take a large share of the $200,000 bond issue for which the Ocean Shore has made application. With this money, according to the railroad officials, the steam trains can be supplanted by modern electric cars run over a single track route with a sufficient number of sidings, as far as Half Moon Bay, the present terminal. It is estimated on the basis of last year's business that the Ocean Shore, if it had been operated by electricity instead of steam, would have shown earnings of from $25,000 to $30,000.

SACRAMENTO, CAL.—The judgment of the Yolo County Court in allowing the condemnation by the Vallejo & Northern Railroad of 1041 acres of land with a river frontage of 2500 ft. of the Reed Orchard Company lying on the Yolo bank of the Sacramento River, between M and T streets for wharfage purposes, at the price of $104,100, is reversed in a decision handed down by the appellate court. The opinion, written by Justice Burnett and concurred in by Justices Chipman and Hart, also denied the request of the railroad that the appeal of the Reed Orchard Company be dismissed. The long litigation over the river frontage is thrown back into the courts for another trial, with the question again to be determined of the right of the company to condemn this amount of land and the price that should be paid. A new trial will have to be heard in the Yolo county court.

SAUSALITO, CAL.—All opposition in the board of trustees to Sausalito's two proposed street railways was swept aside at a meeting of the council this week and the franchises were passed to print without a dissenting vote. The Marin County Electric Railways Company proposed to connect this city with Mill Valley and way stations, as well as to give both towns a street car service. The other application is that of Dr. A. H. Vance and Attorney George Harlan, representing San Francisco capitalists, for a right of way along Excelsior lane for funicular railway purposes. The Marin Electric Railways Company has secured its Mill Valley and county franchises. The funicular railway company proposes to build and operate a railway similar to that of the Fairfax Manor Company in Fairfax, making available for residence a large part of the hill section of Sausalito that is not marketable under the present conditions. The road will be about a quarter of a mile long at the outset, and will attain an elevation of about 450 ft.

## TELEPHONE AND TELEGRAPH.

LOS ANGELES, CAL.—An ordinance has been passed creating a bureau of fire alarm and police telegraph in the department of electricity.

SALEM, ORE.—The state railroad commission has granted a request of the Aurora Mutual Telephone Company to increase its rates from 75 cents a month to $1.25 on each telephone.

PACIFIC, WASH.—A number of farmers have organized between here and Sumner to install a farmers' telephone system. They have been granted a franchise by the Pierce county commissioners.

FLAGSTAFF, ARIZ.—District Manager R. H. Buehler of the Mountain States Telephone Company, states that material for a telephone system is being assembled here and work will soon commence.

CENTRALIA, WASH.—The commissioners of Lewis county will meet March 2d to hear the application of the Bunker Creek Rural Telephone Company, and Mary E. Coffman for authority to erect telegraph and telephone lines over the Robert Mauermann Road, Stearns or Bunker Creek Road, Blake or Deep Creek Road, J. E. Bunker Road and Math. Kobe Road. They will also on the same day hear the application of the Crego Telephone Company for authority to construct telephone and telegraph lines over the Newukum and Boistfort Road, Chas. A. Cousens Road, Christ Frogner Road, J. Bona Road and others.

SAN FRANCISCO, CAL.—Consideration of telephone rates was begun a few days ago by the supervisors' committee having this work in charge. In its statement the company points out that the rates have been reduced every year for the last five years and have reached a point that it is not paying a return upon the investment, and it asks to be allowed to make at least 8 per cent. The company says that the net revenue allowed by last year's rates amounted to $300,976, and that this is only 1.82 per cent return on the investment. The company asks that this be substantially increased this year. The company has 111,165 telephones in this city or 23.3 telephones to every 100 inhabitants, and it says that large additions will be required to this system between now and the time of the opening of the Exposition. While the rates have been cut 24.9 per cent, the company says the expenses have not decreased in proportion, and only show a reduction of 10.1 per cent. The payroll of the company is said to be $2,766,294 a year.

## WATERWORKS.

PENDLETON, ORE.—Pendleton will vote in the near future on a $40,000 bond issue for the construction of a gravity water system.

EL CENTRO, CAL.—An ordinance has been passed providing for the issuance and sale of bonds in the sum of $50,000 for the purpose of acquiring and constructing a water system here.

SNOQUALMIE, WASH.—An ordinance has been passed providing for the construction and maintenance of a system of waterworks in this town and providing for a bond issue to pay for same.

MONTAGUE, CAL.—Sealed bids will be received up to March 23d on the proposals in connection with the construction of the municipal water system. Segregated bids will be received for different parts of the work.

LOS ANGELES, CAL.—The board of supervisors of Los Angeles county have granted to the Eagle Rock Water Company a franchise to lay, construct and maintain certain water pipes along certain public highways in this city.

MARTINEZ, CAL.—The gas franchise as applied for by Waldo Coleman came up for definite action at the last meeting of the municipal board and was ordered to be advertised for sale to the highest bidder on March 23d.

SAN DIEGO, CAL.—Plans for beginning early construction improvements to the water impounding system are being formed by Engineer H. A. Whitney, as fast as he can assemble data and conduct experiments at Barrett and in Mission valley.

PULLMAN, WASH.—It is proposed to bond the city for $20,000 for the construction of a water system. A new 10 in. main will have to be laid from the new well to the intersection of Main and Alder streets, and it is proposed to erect a 60,000 gallon elevated tank near Kincaid's.

ROSEBURG, ORE.—Councilman J. C. Fullerton introduced a resolution before the council providing for the appointment of a commission of five members not of the city council, to proceed with the investigation of the cost of installing a municipal water system in this city.

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S-7 Staples & Pfeiffer. ..... 102 Steuart Street, San Francisco.

T-1 Thomas & Co., R. ..... (See Western Electric Co.)

V-1 Van Emon Elevator Co. ..... 56 Natoma Street, San Francisco.

W-1 Wagner Electric Manufacturing Co. ..... 13 Rialto Building, San Francisco.

W-2 Western Electric Co. ..... 18 119 East Seventh Street, Los Angeles; 507 Sixteenth Street, Oakland; 689 Folsom Street, San Francisco; 1518 First Avenue, So., Seattle.

W-3 Westinghouse-Church-Kerr Co. ..... Pacific Electric Building, Los Angeles; Pacific Building, San Francisco.

W-4 Westinghouse Electric and Manufacturing Co. ..... 6 50-52 East Broadway, Butte; Van Nuys Building, Los Angeles; Couch Building, Portland; 212 So. W. Temple, Salt Lake City; 165 Second Street, San Francisco; Central Building, Seattle; Paulsen Building, Spokane.

W-5 Westinghouse Machine Co. ..... 141 Second Street, San Francisco.

W-6 Westinghouse Lamp Co. ..... (See Westinghouse Electric and Manufacturing Co.)

W-7 Weston Electrical Instrument Co. ..... 3 682 Mission Street, San Francisco.

W-8 Western Pipe & Steel Co. ..... 444 Market Street, San Francisco; 1758 North Broadway, Los Angeles.

# JOURNAL OF ELECTRICITY

## POWER AND GAS

**Devoted to the Conversion, Transmission and Distribution of Energy**

VOLUME XXXII SAN FRANCISCO, MARCH 7, 1914 NUMBER 10


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# ELEMENTS OF FUEL OIL PRACTICE AND BOILER TESTING

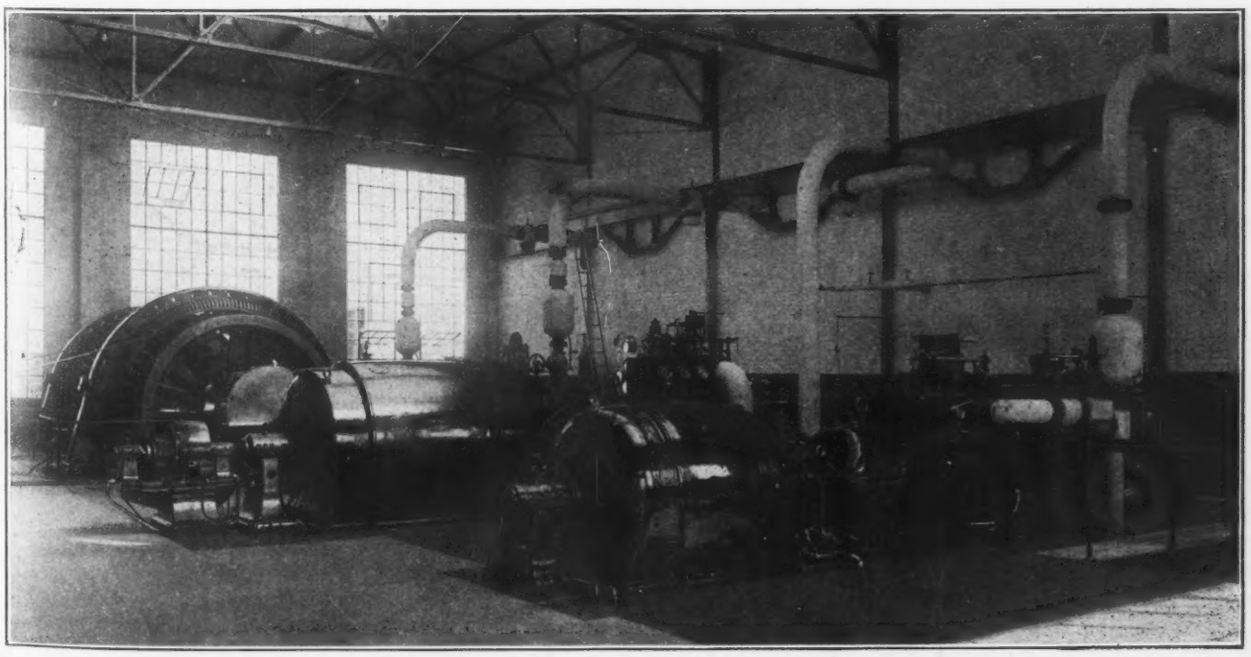
BY ROBERT SIBLEY.

*(This is the first of a series of articles which in their entirety will constitute a complete treatise on steam power plant practice. The author is Professor of Mechanical Engineering at University of California.—The Editors.)*

### The Modern Power Plant and the Reason for Its Existence.

The enormous growth of the electrical industry throughout the world during the past decade has entirely revolutionized methods of power development. Especially is this true west of the Rocky Mountains where gigantic natural water powers have been put to a useful purpose. Owing to the fact, however, that most of the western streams show a great variation in flow, in the different seasons of to depend solely upon water power the year, it is not always possible for the supply of electrical energy. In recent years the advent of crude petroleum upon the Pacific Coast, representing a total in production of 98,000,000 barrels during the year 1913, has made it possible when rainfall or water supply is lacking to cheaply supply the needed power. During certain hours of the day, too, when the so-called peak load conditions are to be met by a central station, additional powers over that possible to supply from the hydroelectric station are found to be necessary. Hence the steam power plant, consisting of large concentrated units, is now recognized as an indispensable auxiliary to continuity of service.

In order that there should be no excessive loss in distribution, these concentrated steam power units are usually found in the heart of the great distribution centers. Especially is this true where abundance of circulating or cooling water may be obtained. Thus we find in central California, Station A and Station C of the Pacific Gas & Electric Company, and the Fruitvale station of the Southern Pacific Company all situated in the distributing centers of San Francisco and its immediate vicinity. In Los Angeles we find that the Redondo plant of the Pacific Light & Power Corporation and the Long Beach plant of the Southern California Edison Company, owing to the lack of



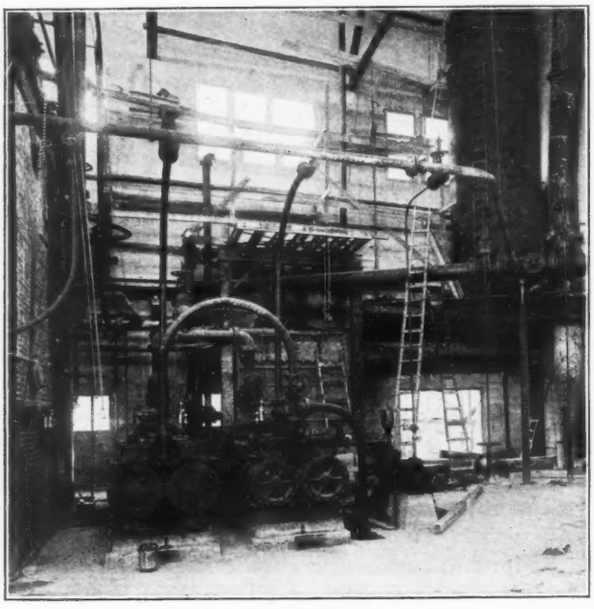
Interior of a Modern Horizontal Steam Turbine-Driven Electric Power Plant.

abundant cooling water near the distribution center, are situated at a distance from it of some fifteen or twenty miles.

**General Description of the Modern Power Plant.**

It will now be interesting and instructive to examine the details of a typical power installation of the sort just hinted at.

First, we shall describe the so-called steam cycle, or the journey of the steam making water from the time it enters the steam boiler until it has completed its journey through the turbine, or power unit, and returned again to the boiler; secondly, we shall consider the circulating water which is necessary in large quantities to convert the exhaust steam back again into water; and thirdly, we shall touch briefly upon the journey of the oil from the time it leaves the cars at the sidetrack until it disappears from the chimney



Boiler Feed Pumps.

as a flue gas. We shall touch briefly upon the general size and functions of apparatus employed to accomplish these results.

**Steam Cycle.**

**Storage Tank.** The supply of water for steaming purposes is usually brought to a make-up or storage tank from supply wells either on the immediate premises or nearby property. If these are not found, it is brought from rivers, lakes, or other bodies in the vicinity, or in many cases is purchased from some water company supplying the municipality. The storage tanks are varied in size, shape and capacity from a small tank, used as a receiver and hot-well, to a number of tanks, large and small, used for storage purposes only.

The use of storage tanks depends upon the source and quantity of water supplied and the load carried by the plant. Where there is a steady and positive source of supply, the tank may be of small capacity. In some cases where the supply is small and the storage at different periods is unfit for use, larger storage and settling tanks are required, and at times even filtration and cleaning tanks also are employed.

**Pumps for Storage Supply.** The tanks above alluded to, are filled either by pumps, gravitation flow, syphons, or piping from a water company's main. There seems to be no standard type of pump. Both reciprocating and rotary appear in standard practice. On the other hand, many plants have wells, and water is lifted by air pressure. This, on account of the total absence of working parts, is particularly useful where there are a number of scattered wells, and, also, when it becomes necessary to handle dirty water, that is, water containing sand, grit and dirt in suspension. This air lift consists of a partially submerged water pipe and an air supply pipe. The casing of the well is driven below the lift pipe. The lift pipe is set in the well either with air surrounding it between the pipe and the casing or with a cap over the casing, thus making the space in the casing air-tight. In some instances the well casing is used directly as the lift pipe.

**The Hot-Well.** The water from the storage tanks is either pumped or is caused to flow by gravity to a so-called hot-well. The hot-well is a tank which stores the water before it passes to the feed-water heater. It receives water from the condenser and admits an additional supply from the storage tanks to meet the needs of steam generation.

**Feed-Water Pumps.** From the hot-well, water is taken through feed-water pumps into the feed-water heater. The function of a feed-water heater is to heat the entering water to a temperature approximating that of evaporating conditions in order to keep the boiler at as even a temperature as possible and at the same time to put the exhaust steam from the auxiliary apparatus to some useful purpose.

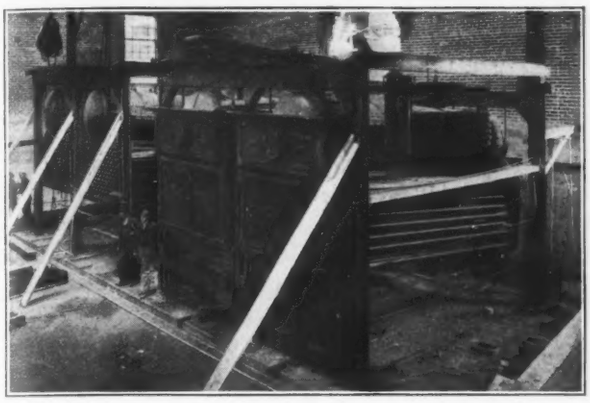
Feed-water heaters are divided into two general types: open and closed. In the open heater the steam comes in direct contact with the cooling water, and if there is a sufficient quantity of steam, it raises the water to 212 degrees F., the excess steam passing to the atmosphere. In a closed heater, on the other hand, the water is not exposed to the air and, if necessary, can be raised to boiler temperature. The water from a closed heater is as a rule much cleaner, since at high temperatures the deposits and minerals in solution are precipitated.

In steam plants where closed feed-water heaters are used, the boiler feed pumps are placed before the heater, thus pumping through the heater to the boiler. When open feed-water heaters are used, however, the boiler feed pumps are placed between the heater and the boiler.

**Economizers.** Economizers are sometimes installed in place of feed-water heaters. The economizer is a series of pipes through which the feed-water passes, placed in the path of escaping gases from the boiler furnace.

**The Boiler.** The boiler next receives the water from these heaters and converts it into steam at the desired pressure and temperature. The main types of boilers are water and fire tube. Modern practice indicates a decided preference for water tube boilers. A water tube boiler consists of steam and water drums placed on the top and a mud drum placed below, the two being connected by a series of tubes filled with

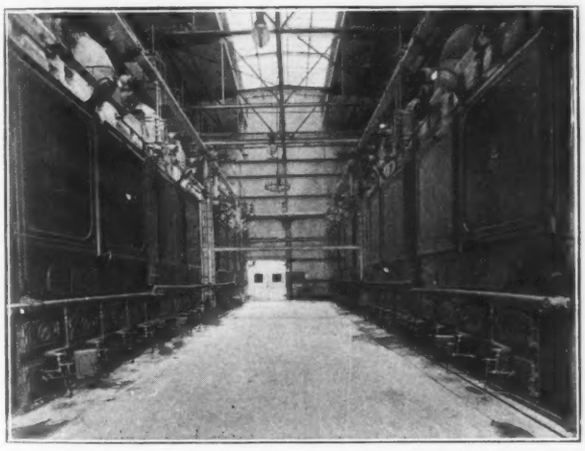
water or steam. The fire is below these tubes, and the heat from the furnace is made to pass around



Boilers in Course of Erection Showing Water Tubes.

them several times by means of headers or partitions, thus supplying heat for steam generation.

**The Superheater.** The water being thus converted into saturated steam by heat from the furnace of the boiler, is next passed through a series of tubes known as a superheater. These tubes are ex-



A Typical Arrangement of Boiler Installations.

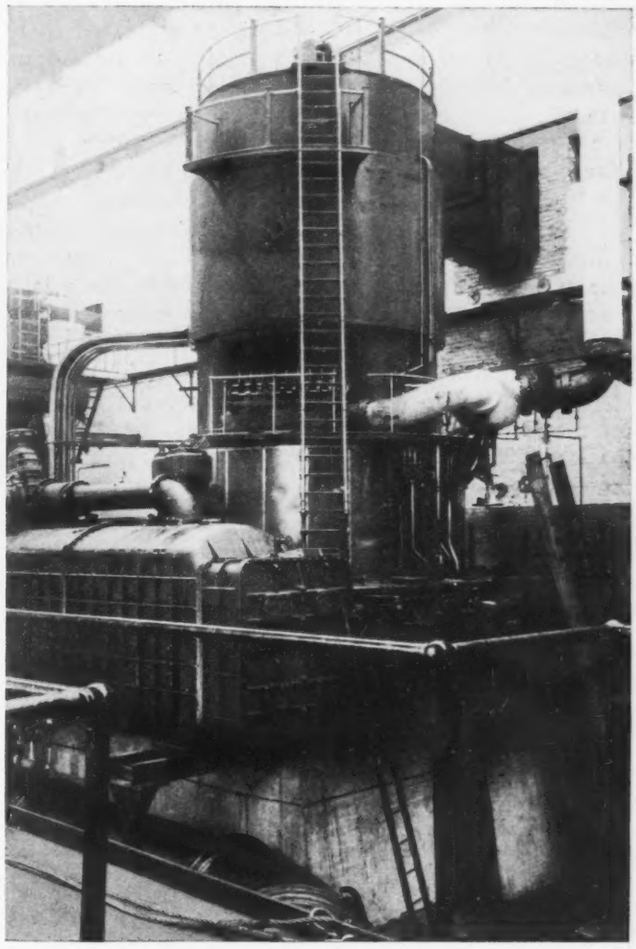
posed in a heated portion of the furnace and thus the steam is raised to a point much higher than its saturated temperature.

**The Separator.** From the superheater the steam passes through suitable piping to a separator, placed between the boiler and the engine, or between the boiler and the turbine. This separator is placed as near the power unit as possible in order to remove all condensed steam that may be found in the pipes. One form of separator performs its function by quickly reversing the direction of the flow of steam, thus depositing the water into a drip which is drained off into the condenser. Another form gives a rotary motion to the entering steam thus hurling particles of water off by centrifugal force and collecting in proper receptacles. Again baffle plates are at times employed wherein the flow is interrupted by corrugated or fluted plates, and the particles of water adhering to these, are then drained off.

**Reciprocating Engine or Steam Turbines.** The steam next goes from the separator to the main power generating units. The main units in earlier practice were reciprocating engines, in modern installations they are steam turbines.

Reciprocating engines may be divided into several classes, the details of which will not be outlined in this general discussion. Suffice it to say, however, that the main principle upon which reciprocating engines act is that steam enters a cylinder under pressure, thus forcing ahead a piston which is connected to a crank arm, thereby causing rotation and the consequent generation of power.

Steam turbines are divided into two general classes known as impulse turbines and pressure turbines. In the impulse turbine steam is allowed to expand in passing through a nozzle, thus causing the steam to travel at an enormous velocity. The steam, having



Vertical Type Steam Turbine With Condenser Base.

acquired this velocity by impinging against movable blades, causes rotation and the consequent generation of power. In the pressure turbine, however, the steam is allowed to enter the buckets or rotating vanes at a comparatively low pressure. These vanes are so designed that the steam may expand in this movable portion and by means of its expanding pressure cause rotation and hence the generation of power.

Turbines as a general rule have two other classifications known as vertical and horizontal. The vertical turbine revolves upon a vertical shaft, which is supported at the bottom by a thin film of oil under

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S-7 Staples & Pfeiffer.
102 Steuart Street, San Francisco.

T-1 Thomas & Co., R.
(See Western Electric Co.)

V-1 Van Emon Elevator Co.
56 Natoma Street, San Francisco.

W-1 Wagner Electric Manufacturing Co. 13
Rialto Building, San Francisco.

W-2 Western Electric Co. 18
119 East Seventh Street, Los Angeles; 507 Sixteenth Street, Oakland; 689 Folsom Street, San Francisco; 1518 First Avenue, So., Seattle.

W-3 Westinghouse-Church-Kerr Co.
Pacific Electric Building, Los Angeles; Pacific Building, San Francisco.

W-4 Westinghouse Electric and Manufacturing Co. 6
50-52 East Broadway, Butte; Van Nuys Building, Los Angeles; Couch Building, Portland; 212 So. W. Temple, Salt Lake City; 165 Second Street, San Francisco; Central Building, Seattle; Paulsen Building, Spokane.

W-5 Westinghouse Machine Co.
141 Second Street, San Francisco.

W-6 Westinghouse Lamp Co.
(See Westinghouse Electric and Manufacturing Co.)

W-7 Weston Electrical Instrument Co. 3
682 Mission Street, San Francisco.

W-8 Western Pipe & Steel Co.
444 Market Street, San Francisco; 1758 North Broadway, Los Angeles.